The Southern California Integrated Wetlands Regional Assessment Program (IWRAP)

Volume 1 - Framework for Regional Assessment of All Wetland Classes and Indicators for Estuary and Coastal Lagoon Assessment:

Recommendations by the
Southern California Wetlands Recovery Project
Science Advisory Panel

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LIST OF ACRONYMS

CRAM	California Rapid Assessment Method
EMAP	Environmental Monitoring and Assessment Program
IWRAP	Integrated Wetlands Regional Assessment Program
NWI	National Wetlands Inventory
SAP	Science Advisory Panel (of the Wetlands Recovery Project)
SWAMP	Surface Water Ambient Monitoring Program
USEPA	United States Environmental Protection Agency
WRP	(Southern California) Wetlands Recovery Project

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EXECUTIVE SUMMARY

In 2002, the Board of Governors of the Southern California Wetlands Recovery Project (WRP) endorsed a Science Advisory Panel (SAP) recommendation that a wetlands regional monitoring program be developed for coastal southern California watersheds (Figure ES1). This is important, because neither the progress of regional wetland ecosystem recovery, nor the continued loss and degradation of wetlands from rapid urbanization, has been quantified in southern California, despite extensive expenditures on routine wetland and stream monitoring. A regional wetlands assessment program provides a cost-effective way to evaluate the status and trends in extent and condition of wetland and riparian areas, and to assess the WRP's progress toward achieving its regional wetland recovery objectives. **WRP partners can use the data from a regional monitoring program to:**

- Evaluate recovery priorities and progress;
- Allocate public funds in ways that result in a lasting regional impact;
- Answer wetland management information questions;
- Streamline reporting of monitoring data, making them more accessible for routine scientific evaluation of restoration and management techniques; and
- Verify the effectiveness of wetland regulatory and management policy, both at the level of the region, and at wetlands where site-specific monitoring is conducted.

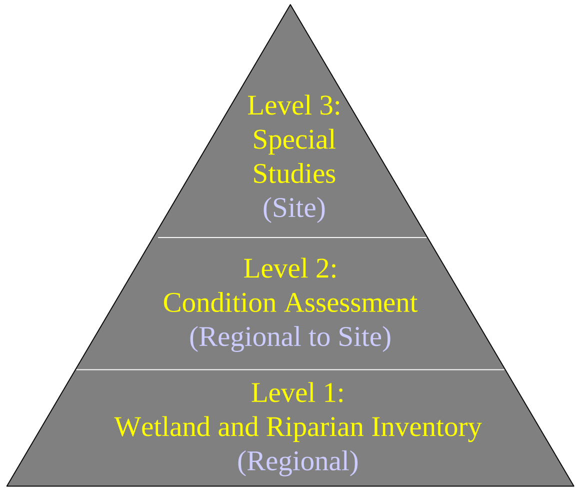
This position paper provides a general framework for the southern California **Integrated Wetlands Regional Assessment Program (IWRAP)**, as well as detailed recommendations for estuarine and coastal lagoon monitoring. The SAP determined that a separate monitoring plan would need to be developed for estuarine, riverine, and depressional wetland classes. The SAP also determined that program development for estuaries should be prioritized based on the amount of WRP funding that had been allocated to their acquisition and restoration. If the WRP chooses to implement the IWRAP, the following wetland-management **information and tools** will become available:

- **Wetland Condition Data** - data relating to the status of, and trends in, southern California wetland condition over time;
- **Inventory** - Maps of wetland and riparian habitat in southern California;
- **Project Tracking** - A record of project-related changes in wetland and riparian habitat acreage over time;
- **Monitoring Protocols** - Standardized methods to monitor wetland extent and condition; and
- **Information Management System** - A database and information-management infrastructure for storing and sharing regional data with multiple user groups.

Figure ES1. Map of southern California showing location of coastal watersheds in which Southern California Wetland Recovery Project activities occur and the geographic scope of the IWRAP.

Framework for a Regional Monitoring Program

The IWRAP regional monitoring program is based on a three-tiered assessment approach (Figure ES2) that integrates monitoring at varying spatial scales and levels of intensity. *Level 1* of the three-tiered approach consists of maps of wetlands and riparian habitat. *Level-2* assessment measures resource condition and stressors on a regional scale. *Level 3* is the most intensive level of assessment, and it addresses detailed questions about stressors and condition on a site-specific scale. It is currently the most commonly conducted form of monitoring in southern California wetlands. Restoration-project monitoring is an example of a *Level-3* assessment activity.



Parenthetical text refers to the spatial scale at which the assessment occurs within each level.

Figure ES2. Schematic of three-tiered approach to regional wetland assessment.

The information derived from the three tiers of the IWRAP is complementary and interdependent. *Level 1* provides an inventory of wetland acreage and distribution, which can be used to track net changes over time. In addition, the resulting wetland and riparian maps also provide the basis for selecting sites for *Level-2* assessment. *Level-3* studies provide insights into the condition of specific sites (*e.g.*, pre- or post-restoration). This information is much more meaningful when viewed within the context of *regional* wetland condition, which is assessed via *Level-2* monitoring.

Recommendations for Regional Monitoring of Estuaries and Coastal Lagoons

Responsiveness to management needs

In order to develop a program as responsive as possible to needs of wetland managers, the SAP consulted with the WRP Managers Group, as well as other agency staff responsible for wetland regulation and management. Through these interactions, the primary wetland management information needs for the region were identified and prioritized. This information formed the basis upon which the IWRAP was developed.

General monitoring design

Monitoring design concerns the way in which each of the indicators of wetland condition will be assessed in space and time. *Level-1* assessment is comprehensive, in that *all* wetlands and riparian areas will be mapped throughout the region. In addition, the SAP recommends that all "projects" (*e.g.*, restoration and mitigation) that affect wetland acreage be tracked. For *Level-2* monitoring, the SAP recommends a "probabilistic" sampling design, in which a subset of sites (*e.g.*, N=30) are randomly selected and sampled. This design yields a statistical estimate of condition for the entire region sampled. For some indicators in *Level-2* monitoring, estuaries and lagoons should be stratified (divided) into two size classes: small and large. A minimum of 30 random sites should be sampled for each size class (for a total of 60 sites). While probabilistic subsampling for *Level-2* assessment facilitates the formation of conclusions about regional conditions, it does not allow for conclusions to be drawn about specific sites. This information need is addressed by *Level-3* assessment, which occurs through sampling at targeted estuaries for which specific studies or monitoring are required. Depending the on the indicator, SAP recommends that sampling for the IWRAP occur once every 5, or 10, years. If possible, sampling should be conducted concurrently (within the same year) for all sites rather than on a rotating basin basis for a subset of sites.

Indicators of wetland condition and assessment questions

The SAP articulated wetland-management information needs for the region in the form of *assessment questions*, which identify both the most appropriate indicators of wetland condition and the way in which they should be measured. The indicators serve to assess the spatial extent, distribution, and condition of wetlands in the region. *Level-1* assessment questions are addressed through region-wide mapping of wetlands and riparian habitat, to be updated every 10 years. *Level-2* indicators are used to assess condition in terms of hydrology, sediment, contaminants, biota, and surrounding landscape (Table ES1). In addition, the California Rapid Assessment Method (CRAM), a field-based method that uses a finite set of observable field indicators to provide a general assessment of wetland condition, is a central component of *Level-2* monitoring. *Level-3* activities consist of monitoring at least a subset of the same indicators recommended for *Level 2*, but at a higher spatial and temporal intensity. This allows site-specific evaluations to be conducted in a manner that supports *Level-2* regional monitoring. Additional *Level-3* monitoring may occur to address specific management questions with respect to particular wetlands; however, this level of monitoring should be determined on a case-by-case basis. *Level-3* assessment includes regional tracking of wetland and riparian habitat gains and losses occurring through restoration, conservation, or mitigation projects, as well as impacts related to development.

Table ES1. IWRAP recommended indicators of wetland condition.

Assessment Level (Tier)	Indicator Class	Specific Indicator
Level 1	Resource extent	• wetland and riparian habitat extent and distribution, including submerged aquatic vegetation (SAV)[1]
	Stressors	• Landscape Development Intensity Index (LDI) • percent impervious surface for estuarine unique catchments • watershed population of estuaries
Levels 2 and 3	Hydrology	• inlet condition • effective tidal range • salinity
	Physical processes	• bathymetry and elevation
	Biochemistry/ Contaminants/ Eutrophication	• sediment constituents • macroalgal extent and biomass • water column chlorophyll *a* • dissolved oxygen
	Biology	• fish species diversity and abundance • overwintering bird community composition • light-footed clapper rail • Belding's savannah sparrow • infauna diversity & abundance • plant species diversity & abundance • eelgrass depth distribution
	Overall condition	• CRAM attributes and stressors
Level 3	Resource Extent	• changes in wetland acreage, by habitat type, due to projects (Project Tracking)

[1] Submerged aquatic vegetation (SAV) consists of rooted, vascular plant species that live their lives underwater. Examples of SAV include eelgrass (*Zostera* spp.) and widgeon grass (*Ruppia* spp.).

Information management and integration with other monitoring efforts

SAP recommends that the IWRAP take advantage, to the greatest extent possible, of existing monitoring endeavors such as California's Surface Water Ambient Monitoring Program (SWAMP), activities pursuant to local Natural Community Conservation Plans (NCCPs), the Southern California Bight Regional Monitoring Program, various permit compliance and mitigation monitoring programs, and monitoring associated with various grant-funded restoration projects. In addition, SAP recommends that this integration be facilitated, in part, through the development of a tracking system that brings information from the various project-related monitoring efforts together into a single data center.

Conclusion: Benefits of the IWRAP

The IWRAP will produce information and tools to assist wetland agencies and managers in realizing the recovery objectives defined by the WRP. A wetland and riparian habitat inventory; a *Project Tracker* documenting project-related changes in wetland and riparian habitat acreage; protocols for monitoring wetland extent and condition; data describing the status of, and trends in, southern California wetland condition; and an IWRAP database and information-management infrastructure will result from implementation of the IWRAP. Furthermore, the coordination of monitoring activities and sharing of data and information-management infrastructure, made possible through implementation of the IWRAP, will all serve to streamline communal efforts, maximize cost effectiveness, and yield a wetland monitoring program that is beneficial for multiple user groups in southern California.

PREFACE

In 2002, the Board of Governors of the southern California Wetlands Recovery Project (WRP) endorsed a recommendation by the WRP Science Advisory Panel (SAP) that a wetlands regional monitoring program be developed for southern California. The purpose of this program is to evaluate the status and trends of the region's wetlands and to assess the WRP's progress toward achieving its wetland recovery objectives.

This paper provides a detailed conceptual framework for the Integrated Wetlands Regional Assessment Program (IWRAP) and recommendations for monitoring the *extent and distribution* of wetlands of *all* classes, by habitat type. In addition, it provides SAP recommendations for monitoring the *condition* of *estuaries and coastal lagoons* (henceforth referenced as "estuaries" only, for brevity). Analogous recommendations will ultimately be developed and published in separate position papers for riverine and depressional wetlands. Work toward drafting the next position paper, on riverine wetlands, began in mid 2006.

Included in the main body of this paper is a distillation of SAP recommendations on the general design of, and approach to, estuarine monitoring at the regional level and for specific sites. It includes discussion on priority indicators of condition that should be measured, as well as the process of selecting sampling locations, and general approaches to conducting the assessments. More detailed information on the evolution of the recommendations, the rationale behind them, and the specific recommendations for the approach to assessing each indicator can be found in the appendices to this document. Detailed protocols on the methods for conducting the sampling for each indicator, and further analyses, where applicable, will be provided in separate protocols. Work on these protocols began in early 2006.

CHAPTER I: INTRODUCTION

Background

The Science Advisory Panel (SAP) was established by the Southern California Wetlands Recovery Project (WRP) Board of Governors to ensure that the best available science is incorporated into the decision-making processes of the WRP and to advise the Board on regional goals, objectives, project criteria, and priorities. In May 2002, the SAP published a position paper (Sutula *et al.* 2002; Appendix A) recommending the implementation of three major initiatives designed to better support regional planning of wetland recovery. This position paper recommended that the WRP adopt **Quantifiable Recovery Objectives** that form the basis by which to evaluate WRP progress towards "recovery". These objective include:

- Maintain existing, and increase, wetland acreage;
- Recover habitat diversity to reflect historic distribution to the extent possible;
- Restore physical processes;
- Recover biological structure and function; and
- Recover landscape elements of ecosystem structure.

The 2002 position paper also recommended the implementation of a regional monitoring program to measure wetland condition and track progress towards WRP Quantifiable Recovery Objectives.

At the October 2002 WRP symposium, the Board of Governors discussed and concurred with the SAP recommendations and adopted the five Quantifiable Recovery Objectives. In addition, they requested that the SAP further develop detailed recommendations for a wetlands regional monitoring program and present this framework in a position paper.

The purpose of the present position paper is to provide a detailed conceptual framework for an Integrated Wetlands Regional Assessment Program (IWRAP) for the WRP. Its goal is to provide specific recommendations on IWRAP program components, including: technical approach, sampling design, and appropriate indicators of condition for estuaries. The paper covers the basic concepts that apply to the overall structure of the IWRAP as well as basic monitoring recommendations for wetland extent and distribution, in the form of wetland and riparian *inventories*.

Whereas, for inventories, the same approach applies to all wetland classes, the approaches to assessing resource *condition* and *stressors*, at both regional and site-specific levels, are unique to each wetland class. Due to the difficulty in developing a comprehensive monitoring program for all wetland types in the region, the SAP has chosen to define wetland inventory activities for all wetlands types but restrict the definition of *condition-assessment* activities to *estuarine* wetlands for the present position paper, in order to more rapidly produce a product that can be implemented by WRP partners. Estuarine wetlands are a logical starting point because better inventory data exist for this wetland class than any other and there have been more resources directed to major estuarine restoration than any other wetland class. Definition of assessment activities for riverine and depressional wetlands are planned to be phased-in at a later date. Therefore, for general concepts and all inventory monitoring, this paper applies to all wetland classes. However, for the portion of this document concerning condition assessment, only estuarine wetlands will be discussed. The recommendations in this position paper will serve as a prototype and first phase toward the ultimate development of integrated monitoring for other wetland classes, detailed recommendations for which will be provided in subsequent position papers.

Specifying the geographic scope and range of wetland types or habitat that are covered by the IWRAP is important because specification ultimately affects logistical considerations and total costs of the program. The SAP recommends that the geographic scope of the IWRAP include all the southern California coastal watersheds that drain to Pacific Ocean from Point Conception to the border with Mexico (Figure 1).

Figure 1. Map of southern California showing location of coastal watersheds in which Southern California Wetland Recovery Project activities occur and the geographic scope of the IWRAP.

The IWRAP has been designed to directly address the priority wetland management needs identified by the WRP. This intent is reflected in the general goals of the program, which are to:

- Measure the status and trends in condition of wetlands and associated resources in southern California coastal watersheds,
- Provide relevant information on the major anthropogenic stressors impacting wetland condition, and
- Evaluate the effect of wetland management actions on the regional wetland ecosystem.

The SAP envisions that the concepts in this position paper will serve to initiate a dialogue among WRP partners on the IWRAP programmatic structure and technical approach. The authors look forward to feedback from the WRP partners regarding the paper’s contents.

Rationale and Approach

Southern California coastal wetlands and watersheds have been dramatically altered by human activities over the past 150 years (Leet *et al.* 2001). Fragmentation and loss of habitat have resulted in the threatened extinction of numerous wetland-dependent species (Dobson 1997). Furthermore, development pressure on this area continues to be intense, with a doubling of the 1995 population expected by 2020 (San Diego Association of Governments 2000).

The WRP was formed in 1997, in response to a need for increased regional coordination of wetland preservation, restoration, and management. The WRP is now a partnership among 17 state and federal agencies, working in concert with local government, environmental organizations, and scientists to develop and implement a comprehensive plan for preserving and restoring the region's wetlands. Public interest in, and funding for, conservation and restoration activities remains high. Even during recent times of slow economic growth or recession, California voters demonstrated their commitment by approving Proposition 40, which provides funds for state lands acquisitions and clean-water initiatives (Stanley 2002). Since the inception of the WRP in 1997, through March 2006, over $500,000,000 has been spent on WRP Work Plan projects, or an average of $50,000,000 per year.

Neither the progress of regional wetland ecosystem recovery, nor the continued loss and degradation of wetlands from rapid urbanization have been quantified in spite of large sums of money spent each year on routine wetland and stream monitoring. Most existing monitoring is associated with permit compliance or specific project performance, and therefore largely site-specific. Furthermore, existing data cannot be easily integrated because different data sets tend to include different variables, or use different methods, and the resulting data are not always easily accessible. As such, it is not possible to arrive at meaningful regional assessments of wetland condition using current monitoring efforts.

A regional wetlands assessment program that assesses baseline conditions, measures recovery progress, and evaluates the effect of anthropogenic stressors constraining recovery would have many benefits. First, it would help to evaluate recovery priorities and ensure that WRP use of public funds has a lasting regional impact. Second, it would provide an integrated and cost-effective regional approach to addressing the management information needs of WRP partners. Third, it would streamline reporting of monitoring data, making the data more accessible for routine scientific evaluation of restoration and management techniques. Fourth, the assessment program could also serve to verify the effectiveness of wetland regulatory and management policy, both at a regional level and for locations where site-specific monitoring is conducted.

Global Concepts for Regional Monitoring

A number of key concepts apply to all successful environmental monitoring programs. These include the need to establish clearly stated monitoring objectives at the outset. Without such objectives during program development, data resulting from the monitoring effort may not be easily integrated into an overall representation of the status of resources, and important questions may be left unaddressed. The process of defining monitoring objectives to guide the development of the IWRAP followed the framework established in Bernstein *et al.* (1993). This framework consists of four levels representing increasing specificity in defining monitoring objectives:

- *Level I* – creation of a statement of core public and management concerns about the resource in question
- *Level II* – identification of general management and scientific objectives relating to the resource
- *Level III* – definition of measurement goals relating to the status of the resource
- *Level IV* – preparation of specific technical plans and methods for implementing monitoring of the resource

The organization of monitoring objectives in this manner provides a useful framework within which to make logical steps that lead from defining the key resource-management questions (Level I) to specifying the technical detail of monitoring designs (Level IV). It defers the focus on technical details until after the more fundamental goals and priorities of the monitoring program are well defined and agreed upon by all parties.

In developing recommendations for estuarine monitoring, the SAP followed an analogous process that began with taking management questions (presented in Chapter II of this document) that had been defined by the SAP in conjunction with the Managers Group and first articulating a number of "*scientific questions*" addressing each management question. Then "*assessment questions*", addressing each of the scientific questions, were defined. Scientific questions bridge the gap between the general concerns expressed in the management questions and assessment questions, which address the more specific technical detail needed to complete the actual monitoring plans. The assessment questions are significant in that they will ultimately guide the selection and development of protocols and the overall sampling design for the IWRAP. The Bernstein *et al.* process the SAP followed in generating the assessment questions is a stepwise one that guaranteed that the original management objectives were never lost in the course of designing monitoring recommendations. Appendix B provides more information on the process of defining assessment questions based on management concerns.

Coordination of Monitoring Efforts

An important part of an effective regional monitoring program will be coordination among agencies that manage or regulate wetlands. The benefits of such coordination include the ability to pool expertise, agree on regional priorities, define the most appropriate methodologies, share data, and share costs. Opportunities exist for coordinating monitoring efforts among many existing programs, such as the regional monitoring done by California's Surface Water Ambient Monitoring Program (SWAMP) and the compliance monitoring conducted by members of the southern California Stormwater Monitoring Coalition, as well as efforts geared toward compliance with permit conditions (*e.g.*, Section 404, 401, and 1600 permits) and associated with various restoration projects. SWAMP is a statewide program administered by the State Water Resources Control Board with the goal of assessing impacts on water body beneficial uses, locations of polluted sites, areal extent of pollution, and trends in water quality. SWAMP's mission is *"To provide for an integrated evaluation of physical, chemical, and biological characteristics of ambient conditions within California's aquatic systems in relation to human health concerns, ecological condition, and designated uses."* The Stormwater Monitoring Coalition is a partnership of the 11 largest municipal stormwater permittees and regulatory agencies throughout southern California. The Stormwater Monitoring Coalition's mission is to conduct the research necessary to improve stormwater monitoring and develop the tools and information necessary to making informed decisions regarding stormwater management.

There are several aspects of the SWAMP, Stormwater Monitoring Coalition and IWRAP programs that lend themselves to collaborative monitoring efforts. The SAP has already begun developing tools for the IWRAP, such as CRAM, that can provide the other programs with effective and relatively rapid assessment of overall wetland condition. CRAM is the product of a collaborative effort among groups throughout the state and is intended to provide cost-effective, science-based assessments of wetland condition in terms of four wetland attributes: buffer/landscape context, hydrology, physical structure, and biotic structure. In addition, CRAM provides a means of documenting potential stressors to the wetland of interest. CRAM can be used routinely in wetland monitoring and assessment programs, and is being designed to aid in cost-effective, ambient monitoring and assessment at different scales, ranging from individual wetlands to watersheds, regions within the state, and to the state as a whole. The use of CRAM for ambient monitoring will, over time, help wetland managers and scientists quantify the relative influence of anthropogenic stress, management actions, and natural disturbance on the spatial and temporal variability in reference conditions. This information can then be used in the design, management, and assessment of wetland projects.

Collaborative monitoring is of particular importance to the development of a means to assess beneficial uses of *wetlands*. IWRAP could benefit from other programs in that it would have access to broader data on ambient condition of all aquatic resources, not strictly wetlands. Additional information could provide insight into stressors that could be impacting the wetlands. Furthermore, the different programs can all benefit from the sharing of technical expertise, experience, information management, and funding, as well as opportunities for cross-calibration of assessment methods, the development of which is an ongoing process. SAP is taking advantage of the fact that all of these efforts are currently under development, thus providing an efficient means to coordinate efforts and improve the effectiveness of regional monitoring in southern California.

The IWRAP will also seek mutual benefits from intensive monitoring of wetland condition that is being conducted regularly in the context of mitigation and restoration throughout the region. Integration with existing monitoring according to requirements imposed by the United States Army Corps of Engineers, Regional Water Quality Control Board, or California Department of Fish and Game permits can occur, in part, through the development of a project tracking system that brings together information from the various monitoring efforts. This would not only allow for compilation of information, standardization of methods, and the ability to use the results to develop a regional representation of wetland condition, but could also provide a vehicle for cost-sharing and a means to avoid duplication of monitoring effort. Furthermore, from an agency perspective, support for regional monitoring could be derived from the reallocation of the routine sampling efforts currently tied to permits towards regional monitoring. Finally, the standardization of monitoring approaches across regulatory programs would yield a single, large dataset representing a larger sample size than would be realized for each agency separately and thereby increase power of conclusions drawn from the results of site-specific monitoring.

Definitions

Although the SAP acknowledges that there is no single correct definition of "wetlands," development of an integrated assessment program for wetlands requires a working definition of the term. In general, wetlands are zones that lie on a continuum between terrestrial and aquatic environments; often, demarcation of the boundaries is not clear-cut. For the purpose of the IWRAP, the SAP has chosen the United States Fish and Wildlife Service definition of wetlands:

> *"Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For the purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year"(Cowardin et al. 1979).*

With regard to "riparian ecosystems, areas, zones or corridors," definitions can be somewhat confusing, and an explanation is necessary. For the purposes of the IWRAP, a riparian ecosystem is defined as:

> *"...a vegetated ecosystem along a water body through which energy, materials, and water pass. Riparian areas characteristically have a high water table and are subject to periodic flooding and influence from the adjacent water body. These systems encompass wetlands, uplands, or some combination of these two landforms. They will not have in all cases the characteristics necessary for them to be also classified as wetlands"* (Lowrance *et al.* 1983, Mitsch and Gosselink 1986).

This definition encompasses areas that are an integral part of the wetland ecosystem. The terms "riparian areas” or “zones" are sometimes used to refer to the transitional areas upland of wetlands that either 1) support predominantly mesophytic vegetation (trees, shrubs and herbaceous cover), or 2) have soil that is predominantly non-hydric. Riparian areas are not just unique to the upland transition zones of riverine wetlands (in linear corridors), but can also be found adjacent to palustrine, lacustrine and estuarine wetlands.

For the purposes of this document, the term "wetland ecosystem" includes the wetlands, adjacent transitional deepwater, and upland habitats. These adjacent habitats, which may include riparian areas, serve a role critical to the ecological function of the wetland, and are an important and integral part of WRP preservation, restoration, and enhancement activities.

For the purposes of the IWRAP, estuarine wetlands are defined as:

"…subtidal and intertidal habitats that are semi-enclosed by land, have access to the open ocean, and in which ocean water is at least occasionally diluted by freshwater runoff from the land."

Definitions of other wetland classes, some of which will be the subject of future position papers, are provided in Appendix C.

IWRAP Geographic Scope

Identification of the boundaries of estuarine wetlands to be included in the IWRAP requires a definition of estuarine habitat with respect to the upland, oceanic, and freshwater boundaries. The upland boundary is defined as the limit of habitat dominated by salt marsh vegetation. As such, it will generally extend a short distance from the high-water line corresponding to high tides. The oceanic boundary is defined as the oceanward limit of that which can be described as estuarine habitat based on the classification system of Cowardin *et al*. (1979): *The Estuarine System extends (1) upstream and landward to where ocean-derived salts measure less than 0.5‰ during the period of average annual low flow; (2) to an imaginary line closing the mouth of a river, bay, or sound; and (3) to the seaward limit of wetland emergents, shrubs, or trees where they are not included in (2). The Estuarine System also includes offshore areas of continuously diluted seawater*. Part two (2) of this definition is interpreted as including enclosed bays, ports, and marinas along the Southern California Bight that are protected to some degree from full wave action, as well as any deepwater habitat contained within them. In addition to the areas included on the basis of these boundary definitions, all intertidal habitat, as well as portions of non-tidal habitat that are included within the confines of the stated boundaries, are also considered estuarine wetlands. The included non-tidal areas may be a part of historically tidal estuarine wetlands that have been cut off from tidal activity due to anthropogenic activities. An example of such areas would be relict salt marsh plains that are no longer regularly inundated by tidal waters due to the construction of berms and/or levees.

Another important consideration in defining the IWRAP sample frame is the context in which the results of the monitoring will be interpreted. Most of the historical wetland acreage in southern California, particularly in coastal areas, has been developed and no longer performs wetland functions. The condition of areas that have been paved over, or otherwise altered such that they no longer function as wetlands, is currently not monitored. Ideally, the full historic extent of wetlands would be included in the IWRAP sample frame, such that the results of the monitoring would reflect the change in wetland extent and condition, by habitat type, since pre-settlement times. This would better reflect the net sum of anthropogenic impacts to the region's wetlands throughout history. In addition to losses, historic information would also shed light on what present-day wetlands were anthropogenically created. While an accounting of wetland changes since pre-settlement times would be very valuable to the management, regulatory, and political communities, it is not currently feasible to develop a sampling frame to ensure inclusion of all historic wetland acreage, because the exact extent of historic wetlands, by habitat type, in coastal southern California is unknown. The SAP does, however, recommend that a study of historic ecology ultimately be conducted within the WRP study area. The information from such a study would provide a context within which to determine the changes in wetland extent and condition, by habitat type, resulting from anthropogenic influences throughout history, thereby establishing a benchmark for wetlands recovery goals.

The sample frame for the IWRAP will reflect boundaries with ecological meaning, but will not necessarily conform to the boundaries of jurisdiction of agencies that will use the results of the monitoring. Because of the inconsistency in jurisdictional boundaries among wetlands agencies, and of the IWRAP, it will be necessary for the various users of the monitoring data to overlay their own jurisdictional boundaries on the IWRAP sample frame in order to determine how the results of assessments correspond to their own areas of interest.

IWRAP Basic Conceptual Approach

The basic conceptual approach of the IWRAP is an integration of three tiers (or levels) of assessment activities. This three-tiered assessment approach is advocated by the United States Environmental Protection Agency (USEPA), and was adopted by the SAP in their 2002 position paper (Sutula *et al.*; Appendix A). In summary, this approach integrates monitoring at varying spatial scales and levels of intensity. Level 1 consists of inventories of wetlands and associated resources. Level-2 assessment goes beyond measuring extent to address resource condition and stressors on a regional scale. Level 3 is the most intensive level of assessment, addressing detailed management questions about stressors and condition on a site-specific scale. The latter is perhaps the most commonly conducted form of monitoring in southern California wetlands. Relying mostly on intense, field-based assessment, the precision of information generated is much higher in Level 3 than in Levels 1 and 2; however, because of the level of effort required, the information is collected at a limited number of targeted sites, and therefore cannot be extrapolated to the region. Restoration-project monitoring is an example of a Level-3 assessment activity. More detailed information on the three-tiered assessment approach is provided in Appendix D.

Document Organization

The remainder of this position paper discusses the genesis of the monitoring recommendations put forth by the SAP and the way in which these recommendations are directly related to the information needs of wetland managers (Chapter II). It also presents each of the "assessment questions," and the indicators measured for each (Chapter III), that form the foundation of the monitoring program. The final chapter discusses the factors that must be taken into consideration in the course of preparing for and implementing the recommended monitoring (Chapter IV). Additional details regarding the indicators to be measured, spatial and temporal aspects of monitoring, and sampling design are provided in the appendices to this document.

Summary of Recommendations

The following section provides a summary of the foundation and scope of the IWRAP and general SAP recommendations discussed in Chapter I of this document.

- *IWRAP* – "IWRAP" is the Integrated Wetlands Regional Assessment Program that the SAP recommends for implementation in order to track WRP progress toward its recovery objectives

- *Geographic scope* – the IWRAP has been designed to cover monitoring in the region spanning all southern California coastal watersheds that drain to the Pacific Ocean, from Point Conception to the border with Mexico

- *Development of monitoring objectives and assessment questions* – the SAP worked in conjunction with the WRP Managers Group to determine priority management concerns, and used the approach of Bernstein *et al.* (1993) to develop assessment questions, based on these management concerns, that ultimately drive the IWRAP

- *Integration with other monitoring efforts* – SAP recommends that the IWRAP take advantage, to the greatest extent possible, of existing monitoring programs such as the SWAMP and monitoring conducted by members of the Stormwater Monitoring Coalition, as well as project-specific monitoring geared toward compliance with permit conditions (*e.g.*, Section 404, 401, and 1600 permits) and associated with various grant-funded restoration projects

- *Project tracking* – SAP recommends that integration with existing monitoring through the conditions imposed by Army Corps of Engineers, Regional Water Quality Control Board, or California Department of Fish and Game permits, as well as grant-funded restoration projects, be facilitated, in part, through the development of a project tracking system that brings together information from the various monitoring efforts

- *Monitoring framework* – the recommended framework of the IWRAP involves monitoring at 3 levels representing varying spatial scales and levels of intensity of effort, after the fashion of the USEPA's three-tiered (three-level) assessment approach; this includes wetland resource *extent* (Level 1 assessment), as well as *condition* at both the regional scale (Level 2), and site-specific (Level 3) scales

CHAPTER II. IWRAP DEVELOPMENT: RESPONSIVENESS TO MANAGEMENT INFORMATION NEEDS

This chapter describes the process involved in designing the IWRAP. It begins with the articulation of the principles that guided the development of the program, then presents the priority *management information needs* to be addressed by the IWRAP, and the way in which these relate to the WRP Quantifiable Recovery Objectives. In addition, the chapter discusses the formulation of the “assessment questions” that form the basis for the monitoring recommendations and respond to key management information needs.

IWRAP Design Principles and Development Steps

In developing detailed recommendations on the conceptual framework of the IWRAP, the SAP used several core design principals:

1) Assessment should be linked to key management questions.
2) Assessment should provide a quantitative evaluation of the status and trends of the wetland ecosystem.
3) Assessment should identify the associations between different ecosystem components and the anthropogenic stressors that act upon them.
4) Assessment should be cost-effective, yet scientifically rigorous.
5) The intensity of a specific assessment element should be commensurate with the importance of the management question being addressed by that element.
6) Assessment should be adaptive; choices regarding special studies and other intensifications should be informed by the results of coarser monitoring.
7) Different types/levels of monitoring should be integrated to form a logical overall program.
8) New monitoring elements should be focused on supplementing and coordinating with existing efforts.

With these concepts in mind, the SAP established steps for developing recommendations on specific IWRAP components (Table 1). Phase I corresponds to the activities summarized in this position paper. Phase II follows a period of review and feedback by WRP in which the recommended program components are refined, and a detailed cost estimate is produced.

Table 1. IWRAP developmental phases.

Phase I	Identify regional management issues and questions Define program goals Define geographic scope and coverage of wetland types Review existing monitoring Translate management questions into scientific questions Develop general monitoring design Develop detailed assessment questions Select indicators Determine appropriate sampling designs Identify information management needs Determine preliminary cost estimates
Phase II	Refine general monitoring design Choose methods Define quality assurance protocols Develop information management strategy Determine communication strategy

Regional Management Information Needs

Using the general Quantifiable Recovery Objectives established in the first position paper (Sutula *et al.* 2002; Appendix A), WRP partners identified a variety of issues and concerns regarding the overall status and trends in wetland health. Included in this consideration were the impact of anthropogenic stressors on wetland condition, and the net impact of restoration, mitigation, and management at the project level. The resulting management information needs, stated in the form of questions, are summarized in Table 2. The spatial scales pertaining to these questions range from those that could address restoration or enhancement activities on a site-specific scale (Level 3 of the three-tiered assessment approach; Appendix D) to questions about the status of wetland resources and the effects of restoration or management activities on a regional scale (Levels 1 and 2).

Table 2. WRP general wetland management issues and information needs.

Landscape/Regional Level

- Where are wetlands that need to be protected, restored or managed? (*Level 1*)
- Is the goal of "no-net-loss" of wetlands, based on net change in acreage and wetland function for wetland class or habitat type, being achieved? (*Level 1*)
- What types of wetlands should be the focus of future acquisition and restoration projects? (*Level 1*)
- What is the extent of conversion from one wetland habitat type to another? (*Levels 1 and 2*)
- What are the priority sites for management actions within the region/watershed? (*Level 1*)
- What are the priority stressors that need to be managed, by wetland class or habitat type? (*Levels 1 and 2*)
- How is the WRP contributing to the recovery of the regional wetland ecosystem? (*Levels 1 and 2*)
- How can the connectivity of wetland and riparian habitat be improved? (*Level 1*)
- What are the effects of land-use changes in the watershed on wetlands? (*Levels 1 and 2*)

Hydrology and Sediment Processes *(Levels 2 and 3)*

- Have there been any modifications to hydroperiod?
- Are connections to the floodplain intact?
- What is the integrity of the floodplain with respect to surrounding land use, opportunities for connection/reconnection and barriers affecting flood flows?
- What is the extent of channelization, entrenchment, engineered channels, or modifications to flow?
- What is the extent of problems related to erosion, excessive sedimentation, or scouring?

Biogeochemistry *(Levels 2 and 3)*

- What are the trends in nutrient enrichment and eutrophication in estuaries and streams?
- What is the extent to which contaminants are present in surface waters and soils?
- Are these contaminants bioaccumulating to levels of concern in wetland organisms?

Biological Structure *(Levels 2 and 3)*

- What is the status of the wetland plant community (composition) in terms of health?
- What are the distribution and abundance of invasive plants in wetlands?
- What is the health of native animal communities?
- What are the distribution and abundance of special-status species?
- What are the distribution and abundance of fauna that serve as prey items for birds and fish?
- What are the distribution and abundance of invasive animal species in wetlands?
- What are the regional population trends in birds and fish (wetland-dependent, rare and endangered species)?

The Quantifiable Recovery Objectives specify WRP goals in terms of the ecosystem elements that determine wetland integrity. Generally speaking, the objectives are to maintain and restore, to the greatest extent possible, the following wetland parameters: acreage, habitat diversity, physical processes (*i.e.*, hydrology, sedimentation, and biogeochemical processes), biological structure and function, and landscape elements of ecosystem structure. Therefore, the Quantifiable Recovery Objectives provide a link to the overall WRP Vision, which is to achieve a mosaic of functioning wetland ecosystems for the region. Figure 2 provides a schematic depiction of the way in which these factors are related. It shows that the effectiveness of management actions and the progress of wetland ecosystem recovery can be evaluated on several scales, depending on the management question.

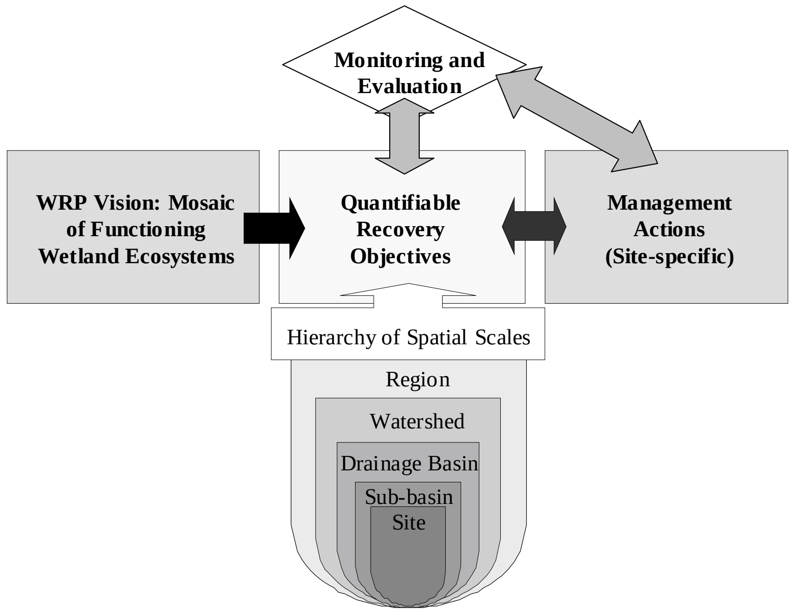


Figure 2. Schematic illustrating linkages between WRP vision, quantifiable recovery objectives, management actions and issues, and wetland monitoring.

IWRAP Conceptual Framework Relationship to Management Information Needs

Because of the number, complexity, and breadth of management issues facing wetland managers, it is important that there be a clear link between management information needs and recommended assessment questions. In developing the IWRAP, this was accomplished via the following process, which is discussed in detail in Appendix B and Table 3.

- Classify and summarize the management issues presented in Table 2 into 8 more generally stated management questions grouped by assessment tier, or level (three-tiered assessment approach; Appendix D). Each level helps to define the spatial scale, as well as the level of intensity, of effort required to answer the question.
- For each general management question, develop a set of “scientific questions” (defined in Appendix B) that addresses one or more of the management issues presented in Table 2.
- For each scientific question, develop a set of specific “assessment question(s)” identifying for each, where possible: the indicator, the target population, appropriate use of reference, unit of analysis, requirements for certainty and precision (i.e., sample design), and appropriate temporal and spatial scales for sampling.

Table 3 illustrates an example of the linkages between the Quantifiable Recovery Objectives, management issues and questions, scientific questions, and assessment questions and output for Level 1. Specific monitoring recommendations for each of the three assessment levels are given in Chapter III of this document.

Table 3. Examples of linkages between quantifiable recovery objectives, management questions and issues, and scientific and assessment questions using Level-1 assessment activities.

Quantifiable Recovery Objective(s)	Increase acreage of functioning wetland and riparian habitat
Management Question	What are the locations and sizes of wetlands in southern California and how are they distributed, by habitat type?
Management Information Needs Addressed	– Where are wetlands that need to be protected, restored or managed? – Are we achieving the goal of "no-net-loss" of wetlands, based on net change in acreage, and wetland function, for wetland class or habitat type? – What type of wetlands should we focus on for future acquisition and restoration? – What is the extent of conversion from one wetland habitat type to another?
Scientific Question	What are the abundance and spatial distribution of wetlands and riparian areas, by wetland class and habitat type, and how are they changing over time?
Assessment Question(s)	What is the change in areal extent and spatial distribution of wetland habitat types in southern California coastal watersheds on a decadal time frame at a base imagery scale of 1:24,000 or smaller? Where is the boundary of potential riverine riparian habitat in southern California coastal watersheds based on floodplain topographic breaks identified from a 10-m digital elevation model? What is the decadal change in areal extent and spatial distribution of riparian vegetation communities in southern California coastal watersheds using a base imagery scale of 1:24,000 or smaller?

Defining Priority Management Questions

The SAP and Managers Groups prioritized a set of management questions as the foundation for the development of the IWRAP. These questions were further divided into Levels 1, 2 and 3, reflecting the assessment tier at which the questions are to be addressed in terms of spatial context (from the level of the region, to site-specific) and intensity of monitoring (from remote sensing, to intensive field work). Table 4 provide the final list of priority management questions for the IWRAP, along with an indication of the level at which each are best addressed. ***These questions are significant in that they provide the foundation for development of the estuarine component of the IWRAP.***

Table 4. General management questions grouped by assessment tier.

Level	Management Question
I	What are the locations and sizes of wetlands in southern California and how are they distributed throughout the region, by habitat type?
2	What is the condition of wetlands and associated resources on a regional scale and how is it changing over time?
	What are the major stressors on wetlands and how are their magnitudes changing over time?
	What are effects of restoration and mitigation projects on the regional condition of wetlands and associated resources?
3	Are wetland restoration and enhancement projects achieving their objectives?
	What are the stressors affecting the condition of wetlands at the project scale?
	What are direct and indirect impacts of urban and agricultural development/infrastructure projects on wetlands and associated resources?
	What are the effects of management actions on the condition of wetlands and associated resources on the project scale?

Summary of Recommendations

The following section provides a summary of the process leading up to SAP's recommendations for the IWRAP, as discussed in Chapter II of this document.

- *Main wetland management information needs* – broadly speaking, the management information needs recognized by the SAP working in conjunction with the Managers Group can be grouped into four categories: Landscape/Regional Level, Hydrology and Sediment Processes, Biogeochemistry, and Biological Structure; identification of specific management information needs within each of these categories led to the articulation of a short list of priority management questions that form the foundation for the IWRAP

- *Linkages between Quantifiable Recovery Objectives and assessment questions* – management information needs were identified as they relate to the Quantifiable Recovery Objectives stated in the first position paper; from the "information needs" was developed a list of priority management questions, which, in turn, were used to articulate scientific questions and then actual assessment questions; assessment questions prescribe exactly what will be measured in carrying out the IWRAP

CHAPTER III. RECOMMENDED GENERAL MONITORING DESIGN, INDICATORS OF ESTUARINE CONDITION, AND ASSESSMENT APPROACHES

Introduction

This chapter provides an overview of the recommended monitoring activities for the IWRAP. It begins with the overall design of the program and then discusses the estuarine indicators to be included in the program, and the assessment questions that prescribe how and when the indicators should be measured. Because implementation of Level-1 inventory is the same regardless of wetland class, the information relating to this level applies to all classes. Conversely, for all Level-2 and -3 monitoring, the recommendations presented here apply to only estuarine wetlands.

General Monitoring Design: Spatial and Temporal

"Monitoring design" refers to the temporal and spatial aspects of sampling for each of the indicators addressed in the IWRAP assessment questions (see next section). From a spatial perspective, sampling can be conducted by exhaustively sampling (censusing) all southern California estuaries in a given sampling cycle. Alternatively, discrete geographical units (such as tidal-channel drainage basins or the assessment areas used in CRAM) within the study area can be defined and *subsampled* in a *random* fashion in order to generate a predetermined number of sampling locations. This latter, "probabilistic" approach is advantageous in that the data from a set of sites chosen in this manner yield a statistical estimate of condition that is representative of the entire area under study. A reduction in effort and cost relative to an exhaustive sampling is another benefit of the probabilistic approach. However, the absence of exhaustive sampling means that detailed information associated with each specific site in the study area will not be generated.

The recommended approach to selection of sampling locations depends upon the indicator being assessed and the level of assessment. **The SAP recommends that the census approach be used for Level-1 assessment, and that a subset of sampling sites be probabilistically (randomly) selected for Level-2. Thirty (30) sampling sites should be assessed for any given Level-2 sample frame. Furthermore, for some Level-2 indicators, estuaries should first be stratified (divided) into two size classes (small and large) such that there are 30 sites within each (for a total 60 sites within the region as a whole.)** The recommended threshold separating small and large estuaries for stratification purposes is 100 intertidal acres. **For Level-3, the recommended site-selection approach depends upon the nature of the monitoring needed at the site in question, and the resources available to carry out the monitoring.** In some cases (for some indicators), it may be ideal to probabilistically select 30 sampling locations within the boundaries of the study site. However, a smaller set of carefully selected, targeted sites may also be adequate for estimating the condition of the site as a whole. Table 5 lists each of the recommended indicators for the estuarine IWRAP and indicates the spatial sampling unit and method of site selection (census *vs.* probabilistic) appropriate for each.

The temporal aspect of monitoring design deals with the frequency with which the indicators of wetland condition should be assessed. Depending upon the indicator, SAP recommends that sampling occur once every 5, or 10, years. Furthermore, **the SAP recommends that sampling**

be carried out synoptically for all indicators. However, if it is not possible to secure bulk funding every 5 (or 10) years, sampling should instead be conducted for 1/5 of the indicators each year. This approach, if necessary, would be preferable to sampling all indicators at 1/5 of the sites each year, because it is more important to have the various sites temporally in sync with one another than to have all the indicators in sync for a subset of sites each year.

A full discussion of the pros and cons of the different sampling approaches, and the rationale for recommending a specific approach for each of the various indicators in the IWRAP, are discussed in detail in Appendix E.

Indicators of Wetland Condition, Assessment Questions, and Monitoring Recommendations

The SAP recommends a series of assessment questions and associated indicators that will provide information to address the identified management information needs. These indicators can be used to assess the extent, distribution, and condition of wetlands in the region. Level-1 assessment addresses extent and consists of 1) region-wide mapping of wetlands and riparian habitat, to be updated every 10 years and 2) tracking of wetland and riparian habitat losses and gains occurring through development impact, restoration, conservation or mitigation projects. Level-2 indicators are measured in the field and used to assess wetland *condition* in terms of hydrology, sediment, contaminants, biota, and landscape context. In addition to these parameters, CRAM is a central component of Level-2 and Level-3 monitoring. **For Level-3, the recommended indicators depend upon the nature of the monitoring needed at the site in question, and the resources available to carry out the monitoring. The SAP recommends that Level-3 monitoring consist of assessing at least a subset of the same indicators recommended for Level-2**. Furthermore, additional Level-3 monitoring that extends beyond the Level-2 indicators may be conducted to address specific management questions at particular wetlands; however, these would be determined on a case-by-case basis.

Due to the similarity between the temporal and spatial aspects of sampling for a number of the recommended indicators, efforts to assess these indicators can be streamlined by measuring them during the same field trips, thus providing a savings in sampling labor and costs. Table 5 provides a breakdown, by indicator, of the recommended sampling frequencies and sampling-location selection methods. This information can be used to determine how monitoring activities specific to different indicators can be coordinated in space and time to improve labor and cost efficiency in implementation of the IWRAP.

The assessment questions associated with each indicator included in the IWRAP for estuarine wetlands are listed in the series of plates in Appendix F. Each plate is labeled with the indicator measured and states the assessment question that addresses that indicator. It also provides the recommended spatial and temporal sampling designs and a brief description of the approach to measurement of the indicator, as well as the anticipated assessment outputs and management uses of the output.

For each indicator, background information about existing monitoring efforts, as well as an explanation of the relationship between the assessment questions and the management needs in response to which they were designed is provided in more detail in Appendix G (for Level-1 assessment questions) and Appendix H (for Levels 2 and 3). These appendices also provide a more in-depth description of the rationale behind the choice of each indicator and assessment question and a more detailed description of the recommended sampling methodology. Appendix I gives an overview of existing Level-3 monitoring efforts and also discusses different potential types of Level-3 monitoring for the IWRAP. Because the SAP recommends that the same assessment questions and indicators that were selected for Level 2 form the basis of Level-3 monitoring for the IWRAP, the questions and indicators are not reiterated in Appendix H. Only *Project Tracking* is discussed in detail, as it pertains to Level-3 assessment, but not Level-2.

Table 5. IWRAP indicators and recommended spatial and temporal monitoring parameters.

Indicator	Assessment Unit	Spatial Sample Design	Frequency (Years/Cycle)
Hydrology: • inlet condition • effective tidal range • salinity	Estuary	Probabilistic (N = 30)	5
Eutrophication: • water-column chlorophyll *a* • dissolved oxygen	Estuary	Probabilistic (N = 30)	5
Biology: • diverse and abundant fish species • light-footed clapper rail • Belding's savannah sparrow	Estuary	Probabilistic (N = 30)	5
Biology: • overwintering bird community composition	Estuary	Census	5
Overall condition: • CRAM attributes and stressors	CRAM assessment area	Probabilistic (N = 60)	5
Biochemistry/Contaminants/Eutrophication: • sediment constituents • macroalgal extent and biomass	Area	Probabilistic (N = 60)	5
Biology: • infauna diversity & abundance • eelgrass depth distribution	Area	Probabilistic (N = 60)	5
Biology: • plant species diversity & abundance	Third-order drainage basin	Probabilistic (N = 60)	5
Resource extent: • wetland and riparian habitat extent and distribution (*including submerged aquatic vegetation, SAV*) • changes in wetland acreage and condition by habitat type (Project Tracking)	Area	Census	10
Physical processes: • bathymetry and elevation	Estuary	Census	10
Stressors: • landscape development intensity index • percent impervious surface for estuarine unique catchments • watershed population of estuaries	Estuary	Census	10

Monitoring with Respect to Specific Estuaries

Sampling-site selection for IWRAP Level-2 monitoring is conducted based on geospatial sample frames that are specific to certain sets of indicators (Appendix E). An example of one sample frame would be: *all the intertidal acreage within the Southern California Bight*. Another would be: *all shallow-subtidal acreage within the Bight*. Because different indicators are applicable for assessment in different habitat types, and not all estuarine wetlands along the southern California Bight possess all estuarine habitat types, not all indicators are candidates for measurement in all estuaries in the IWRAP study region. Delineation of the sample frames for the region will reveal where each of the indicators can potentially be assessed.

Important Indicators Not Currently Included in the IWRAP

The list of indicators in Table 5 represents what were considered to be priority indicators of estuarine condition for the purposes of the IWRAP. It should be noted that indicators of some very important ecological processes were not included because there is a limit to the number of indicators that can be feasibly assessed through the IWRAP. However, another ambient monitoring effort conducted in the WRP study region, the *Southern California Bight Monitoring Program* encompasses nearshore waters and addresses a number of indicators. The Bight program covers a geographic range that is essentially contiguous with, or overlapping that which is defined for the IWRAP. The Bight Monitoring Program focuses on marine waters, coastal harbors, and embayments; whereas, the IWRAP will focus on coastal estuaries and lagoons. As such, the combination of the two programs can be viewed as a reasonably comprehensive assessment of the condition of coastal wetlands and the nearshore environment. Some of the indicators that are of interest to wetland managers, but not covered by the IWRAP, are addressed in the Bight Monitoring Program. An example of such an indicator is the deepwater fish community. Only fish that occupy shallow, subtidal habitats in tidal creeks are currently recommended for IWRAP assessment. However, important fish communities are found in deepwater habitat of lagoons, marinas, and harbors. The fish community in these zones is not included in IWRAP monitoring, but is part of the Bight program. In order to take full advantage of efforts such as these, the IWRAP will be coordinating with the Bight program and capitalizing on opportunities for data sharing.

Summary of Recommendations

The following section provides a summary of the SAP's recommendations for the IWRAP, as discussed in Chapter III of this document.

- *Spatial monitoring design* – the SAP recommends that Level-1 questions be assessed through a census approach, whereas Level-2 questions should be addressed by selecting sites through subsampling (using a probabilistic design), and Level-3 questions should be addressed through sampling at targeted estuaries where specific studies or monitoring are already being conducted

- *Stratification* – in the case of Level-2 assessment, the SAP recommends that a subset of sampling sites be probabilistically (randomly) selected; 30 sampling sites should be assessed for any given Level-2 sample frame; for some Level-2 indicators, estuaries should first be stratified (divided) into two size classes (small and large), before drawing samples, such that there are 30 sites within each class (for a total 60 sites within the region as a whole)

- *Temporal monitoring design* – SAP recommends that sampling be carried out synoptically for all indicators, which are to be sampled over 5-, or 10-, year intervals, depending on the indicator

- *Level-3 monitoring indicators* – the SAP recommends that Level-3 monitoring consist of monitoring at least a subset of the same indicators recommended for Level-2; additional indicators that are not part of Level-2 may also be incorporated, according to the goals of the project in question

CHAPTER IV. IWRAP IMPLEMENTATION

Introduction

The previous chapters in this position paper provided an account of the SAP's recommendations for the IWRAP. This final chapter introduces the logistic and administrative issues that must be taken into consideration for implementing the IWRAP.

General Approach for Issues Relating to IWRAP Implementation

Phasing of IWRAP Implementation

While it would be ideal for the IWRAP to be conducted exactly in the manner recommended by the SAP (*e.g.*, for Level-2 monitoring, assessing all indicators at all sampling sites once every five years), funding constraints may limit how many of the recommendations can be carried out during any given sampling cycle, especially in the early years of implementation, when stakeholders and partnerships are still being developed. Therefore, it may be necessary to phase implementation of the IWRAP, which would involve prioritization of monitoring efforts. The core elements (indicators) of monitoring that should be prioritized are provided in Table 6.

Table 6. Priority indicators recommended for assessment in the case of phased IWRAP implementation.

Assessment Level	Priority Indicators
1	• Wetland maps, by habitat type
2 and 3	• CRAM • Inlet condition • Tidal range • Salinity • Dissolved oxygen • Plant community composition

Implementation considerations

- **Data collection by a single party –** A labor force of data collectors is one of the fundamental needs for implementation of the IWRAP. A single organization should be in charge of overseeing the effort, so that it will be centralized and as well organized and efficient as possible. While data collection for Levels 1 and 2 should be carried out by a core group of individuals, Level-3 data will be collected by numerous parties, who are already monitoring mitigation and restoration project sites and reserves. An IWRAP Administrator will need to be identified. This individual will manage all operations and devise a system for keeping track of all parties submitting monitoring data.

- **Integration with existing programs –** Numerous wetland-monitoring efforts are ongoing throughout the IWRAP study area. Depending on the degree of overlap of the indicators and protocols employed by the various programs with the recommended IWRAP indicators, it may be possible to leverage existing monitoring programs in ways that are beneficial to all parties involved. A list of some existing monitoring efforts and the IWRAP indicators they address is provided in Table H1 in Appendix H. Although no single monitoring effort in southern California estuarine wetlands assesses all of the indicators recommended for the IWRAP, each of the indicators is assessed in at least one program or estuary.

Quality Assurance

An important component of IWRAP implementation will be the development of a Quality Assurance Plan for the program. The Quality Assurance Plan should integrate all the technical aspects of IWRAP implementation in order to provide a "blueprint" for obtaining the type and quality of data and information needed for regional assessment of wetland extent and condition. The IWRAP Administrator will be responsible for seeing that all requirements of the Quality Assurance Plan are met in the course of conducting the monitoring.

- **Protocols –** Among wetlands regulatory agencies, there is currently little in the way of integration of monitoring efforts to generate a "big picture" of the condition of wetland resources. Many agency programs do not follow strict standards on specifically what, and how, to monitor. As a result, there tends to be little consistency from project to project in terms of the monitoring results generated. Regional Water Quality Control Board and Army Corps of Engineers staff members have commented that standardized protocols for assessing the IWRAP indicators that overlap with agency priorities would be welcomed, and the IWRAP is poised to provide much needed standardization of monitoring methods for diverse user groups. A protocol working group is currently developing protocols for use in the IWRAP. Its initial efforts will be coordinated and pilot tested through the Ballona restoration program.

- **Training –** In order to ensure that all IWRAP data collection is conducted in a consistent manner, it will be necessary to conduct training for field and laboratory methods. In addition, the IWRAP Administrator should provide all data contributors with a training session on use of the IWRAP database (see below), and also provide a means for providing technical assistance in the event that problems are encountered during data entry.

Audits – Quality assurance is achieved not only through adherence to a sound Quality Assurance Plan, but also by means of periodic audits of the methodology employed by field and laboratory personnel. A Quality Assurance Officer will need to be identified. This individual will familiarize him/herself with the Quality Assurance Plan and audit Level-2 data-collection crews to ensure their adherence to pre-determined Quality Assurance procedures.

Data management

- **Standard Transfer Data Formats –** The data management system supporting the IWRAP should employ Standard Transfer Data Formats as the data-transfer templates used by all data contributors. Standard Transfer Data Formats seek to encapsulate the lowest common denominator for data expression so that it is compatible with any of a number of common software packages. This means that users are not constrained by the need to possess a certain software package in order to use the database, thus facilitating data exchange between partners, and centralized auto-processing of the regional monitoring data in large batches.

- **Databases** – A database that is able to support queries will need to be developed to store IWRAP data. Because different data contributors may be adding data that correspond to different aspects of the IWRAP, the database interface will need to accommodate these factors. As a corollary to this, an Information Management Plan needs to be crafted to govern all aspects of database management, including a discussion about the lines of data flow, Quality Assurance procedures, analyses, generation of output, and dissemination of results.

- **Web access –** The IWRAP database should be web-based and accessible by all user groups for both entering, and obtaining, the monitoring information.

Reporting

- **Need –** Identifying reporting needs will be the duty of the IWRAP Administrator, with the aid of a Technical Steering Committee. The management objectives of the various stakeholders will need to be clearly identified in order to ensure that monitoring results are communicated to them in a manner that most effectively reflects these needs.

- **Frequency –** Different IWRAP indicators have different recommended intervals of assessment, and as such, the most meaningful frequency of reporting of IWRAP results is something that must be determined (*i.e.*, more frequent, but with less-complete information per report *vs*. less frequent, but more comprehensive).

- **Format –** Because reports will be released at intervals, it will be beneficial to identify a standard reporting format that will be maintained over successive cycles. This will not only make the report easier to produce; it will also make reports more "user-friendly", and facilitate the comparison of results from indicators of interest across sampling intervals. This will allow a better understanding to trends in condition over time.

- **Dissemination –** The final consideration in reporting IWRAP data is who will receive the information, and by what means. Written reports can be disseminated to stakeholders in hard-copy form, at meetings and/or via mail. It would also be desirable to provide access to reports via an online mechanism. A website dedicated to the IWRAP, ideally the same one that provides access to the IWRAP database (see above), could be used for this purpose.

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APPENDIX A: FIRST POSITION PAPER

Improving Regional Planning of Wetland Ecosystem Restoration and Management in Southern California

Southern California Wetland Recovery Project Science Panel Recommendations

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IMPROVING REGIONAL PLANNING OF WETLAND ECOSYSTEM RESTORATION AND MANAGEMENT IN SOUTHERN CALIFORNIA: WRP SCIENCE PANEL RECOMMENDATIONS

EXECUTIVE SUMMARY

The Science Advisory Panel (SAP) was established by the Southern California Wetland Recovery Project (WRP) Governing Board to ensure that the best available science is incorporated into the decision-making processes of the WRP, and to advise the board on regional goals, objectives, project criteria, and priorities. This document is the first in a series of SAP position papers making specific recommendations to the WRP on improving regional planning of wetland ecosystem restoration and management in Southern California.

The recently published WRP Regional Strategy lays out a long-term vision, programmatic goals, and implementation strategies to guide WRP efforts. **To ensure these goals are achieved, the SAP recommends implementing three major initiatives designed to better support regional planning:**

1. **Establish quantifiable recovery objectives;**
2. **Develop decision support tools to aid in prioritizing preservation and restoration activities; and**
3. **Implement a regional monitoring program to measure the progress towards objectives.**

Quantifiable recovery objectives differ from the Regional Strategy goals in that they specify the elements of ecosystem structure and function that must be maintained or restored to achieve "recovery." These scientific criteria form the basis by which to evaluate WRP progress towards recovery. The also constitute the ecological criteria that should be considered in prioritization of WRP preservation and restoration projects. **There are five recommended quantifiable recovery objectives:**

1. **Maintain existing and increase wetland acreage;**
2. **Recover habitat diversity to reflect historic distribution to the extent possible;**
3. **Restore physical processes;**
4. **Recover biological structure and function; and**
5. **Recover landscape elements of ecosystem structure.**

This paper provides a detailed explanation and a rationale for why each objective is important.

Once WRP programmatic goals and quantifiable recovery objectives have been established, the next step is to use them to guide WRP preservation and restoration activities, based on a set of clearly defined priorities. In determining the priority of a project for funding, it is important that its merit to the ecological recovery of the region be clearly established, along with considerations such as technical feasibility and cost. The **SAP recommends that the WRP develop decision support tools to help prioritize the funding of preservation and restoration activities based on the ecological criteria outlined in the quantifiable recovery objectives.** The WRP should undertake two types of decision support projects: 1) establishment of habitat acreage goals, and 2) prioritization of riparian corridor preservation and restoration in coastal watersheds.

Establishment of habitat acreage goals is a means of prioritizing funding to restore the habitat types that have experienced the greatest loss. The targets can be developed by: 1) comparing historical versus present day wetland acreage by habitat type, and 2) developing the habitat acreage requirements of indicator and endangered species using monitoring data and best professional judgment. Implementation of a habitat goals project depends on the development of data sources for this assessment. **The SAP recommends updating the historical and present-day inventories by habitat type, and cataloging monitoring data used to develop habitat requirements for wetland species.** The SAP will provide specific recommendations on establishing targets once the availability and quality of these data are documented.

Given the recent expansion of recovery activities into freshwater wetlands and adjacent riparian habitat, the WRP must develop a coherent strategy for allocating funding to projects in the 10,000 sq km of southern California coastal watersheds. This strategy must be based in part on an assessment of the merits of the project from an ecological perspective. **The SAP recommends that the WRP pursue the development of a decision support tool that will aid in identifying high priority riparian areas for preservation and restoration.** This tool could be used by the WRP Managers group to guide the annual project selection, and by the WRP County Task Forces as a preliminary screening tool to develop priorities for the watershed management planning process.

The SAP has begun to work with the NOAA Coastal Services Center (CSC), WRP Managers group, and Task Forces to adapt the Spatial Wetlands Assessment for Management and Planning (SWAMP) model for WRP use. SWAMP, a NOAA CSC product, is a GIS model used to examine the ecological significance of a wetland to its watershed by assessing contributions it makes to habitat support, water quality, and hydrology. NOAA CSC has agreed to provide the technical expertise to adapt SWAMP for southern California. In developing SWAMP, the WRP will engage in a discussion of the ecological attributes of riparian areas that merit preservation and restoration, and relative importance of each. **The SAP advocates that the WRP support the implementation of the SWAMP decision support tool by:**

1. **Reviewing SWAMP assessment framework currently under development, and**
2. **Developing data layers to support the SWAMP assessment (details on these data layers are given in Section IV.B).**

By setting regional goals and quantifiable recovery objectives, the WRP has clearly defined goals for the program, and the elements of wetland structure and function that must be restored for ecosystem recovery. The next logical step is to implement a monitoring program that assesses baseline conditions, measures recovery progress, and evaluates the effect of anthropogenic stressors constraining recovery. This program would have many other benefits. Among them, it would provide an integrated and cost-effective regional approach to addressing the management information needs of WRP partners. It would streamline reporting of monitoring data, making them more accessible for routine scientific evaluation of restoration and management techniques. The monitoring program could also serve to verify the effectiveness of wetland regulatory and management policy. **Recommendations for the implementation of this program include the need to:**

1. **Update present-day and historical inventories of wetland ecosystems,**

2. **Develop a regional survey of resource condition and stressors,**
3. **Develop a program to monitor success of restoration projects;**
4. **Improve coordination of project-specific monitoring, and**
5. **Develop the administrative infrastructure to support this program.**

The SAP envisions that this position paper will serve to initiate a lively dialogue among WRP partners on ways to improve regional planning, and build support and momentum for the implementation of the three recommended initiatives described in this document. We look forward to feedback from the WRP partners on the contents of this paper. Future position papers will focus specifically on detailing specific assessment frameworks and detailed implementation plans for regional monitoring, habitat acreage goals, and the SWAMP decision support tool.

CHAPTER I: INTRODUCTION

A. Background

The southern California coastal province is a distinct region that extends from Point Conception in Santa Barbara County to Punta Banda, south of Ensenada, Baja Mexico, and includes all watersheds that drain to the Pacific Ocean (Fig. 1). The physical features, climate, and hydrology of this biogeographic province have produced an unusual set of hydrogeomorphic conditions and a diversity of plants and animals that sharply distinguish the region from any other in North America. Southern California's embayments and wetlands are among the most diverse, productive and densely populated habitats on the Pacific coast.

Figure 1. Map of southern California showing location of coastal watersheds where Southern California Wetland Recovery Project activities occur (map courtesy of Lori Sutter, NOAA)

Southern California coastal wetlands and watersheds have been dramatically altered by human activities over the past 150 years (Leet et al. 2001). The fragmentation and loss of habitat has resulted the threatened extinction of numerous wetland-dependent species (Dobson 1997). Development pressure on this area continues to be intense, with a doubling of the 1995 population expected by 2020 (SanDAG 2000).

The Southern California Wetland Recovery Project (WRP) was formed in 1997 in response to a need for increased regional coordination of wetland preservation, restoration, and management. The WRP is now a partnership among 17 state and federal agencies working in concert with local government, environmental organizations, and scientists to develop and implement a comprehensive plan for preserving and restoring the region's wetlands. The Science Advisory Panel (SAP) was established by the WRP Governing Board to ensure that the best available science is incorporated into the decision-making processes of the Wetlands Recovery Project and to advise the Board on regional goals, objectives, project criteria, and priorities. As of October 2000, the WRP Governing Board strengthened the role of the SAP in the WRP, providing funding to support a SAP staff member to facilitate SAP communication with Managers Group and County Task Forces.

Public interest in and funding of conservation and restoration activities remains high. Even in times of slow economic growth or recession, recent California voter approval of Proposition 40 providing funds for state lands acquisitions and clean water initiatives demonstrates this commitment (Stanley 2002). The WRP 2001-2002 work plan called for $50 million dollars in funding for acquisition and restoration projects, with an additional $100 million dollars to be matched by federal, state, local and private sources (WRP 2001). Given this significant taxpayer investment, the WRP must work to assure the most appropriate and efficient use of public funds. In doing so, the long-term effectiveness of wetland preservation and restoration efforts in southern California is one question that the WRP must ultimately address.

B. SAP Recommended Initiatives for Improving Bioregional Planning

Optimally, wetland preservation and restoration should be guided by a regional plan that includes a mix of habitat types, appropriately located within the landscape, to recover regional species diversity. However, the reality is that many projects are approved independently, driven by the needs of the wetland restoration proponent or of the wetland mitigator, or designed to benefit a targeted species without adequate regard for overall habitat requirements. Instead, the restoration efforts of the WRP and its partners should be driven by the regional priority to reestablish habitat types that historically have seen the greatest loss (Zedler 1996).

The WRP recently published its Regional Strategy, articulating the long-term programmatic goals and specific implementation strategies to guide the efforts of the WRP and its partners. The purpose of this paper is to build on this Regional Strategy by setting forth recommendations for improving the regional planning of wetland ecosystem preservation and restoration in southern California. It is our hope that this paper will be used to initiate a dialogue among WRP partners, and build support and momentum for the implementation of three initiatives designed to support better regional planning.

The WRP Science Advisory Panel (SAP) recommends the implementation of three major initiatives. These are the:

1. Establishment of quantifiable recovery objectives for wetland ecosystems;
2. Development of decision support tools to aid the WRP in prioritizing preservation and restoration activities; and
3. Development and implementation of a regional monitoring program to measure the progress towards these objectives.

This paper describes each of these initiatives in detail, as well the perceived need and expected benefits of implementing them. Chapter II includes the background explaining the connection between the WRP Regional Strategy and quantifiable recovery objectives, the philosophy with which the recovery objectives were developed, and a detailed explanation of each of the quantifiable recovery objectives. Chapter III details the development and recommendations for two types of projects that the SAP is advocating that the WRP undertake to provide decision support for prioritizing preservation and restoration activities. Chapter IV describes the need for a regional monitoring program, the recommended approach, the link between recovery objectives and monitoring, and SAP recommendations for implementing this program.

C. Definitions

Terms such as "wetland ecosystems" and "riparian areas" are used throughout this document, and it is important that we define these terms. There is no single correct definition of "wetlands" or "riparian areas." These zones lie on a continuum between terrestrial and aquatic environments, and demarcation of the boundaries often is not clear-cut. For the purpose of this document, the SAP chooses to use the U.S. Fish and Wildlife Service definition of wetlands:

> *"Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For the purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year"(Cowardin et al. 1979).*

The wetland ecosystems of southern California include five types or systems: marine, estuarine, riverine, lacustrine and palustrine wetlands (Cowardin et al. 1979). The glossary at the end of this document gives definitions of each of these types.

The definitions of "riparian ecosystems, areas, zones or corridors" can be somewhat confusing, and an explanation is necessary. The US EPA defines a riparian ecosystem as:

> "*…a vegetated ecosystem along a water body through which energy, materials, and water pass. Riparian areas characteristically have a high water table and are subject to periodic flooding and influence from the adjacent water body. These systems encompass wetlands, uplands, or some combination of these two landforms. They will not have in all cases the characteristics necessary for them to be also classified as wetlands" (EPA 2001).*

This definition encompasses the wetlands that are an integral part of this ecosystem. The terms "riparian areas or zones" are sometimes used to refer to the transitional areas upland of wetlands that either 1) support predominantly mesophytic vegetation (trees, scrub and herbaceous cover) or 2) have soil that is predominantly non-hydric. Riparian areas are not just unique to the upland transition zones of riverine wetlands (in linear corridors), but can also be found in adjacent to palustrine, lacustrine and estuarine wetlands.

For the purposes of this document, we have chosen to use the term "wetland ecosystem" to include the wetlands, adjacent transitional deepwater and upland habitats. These adjacent habitats, which sometimes may include riparian areas, serve a role critical to the ecological function of the wetland, and are an important and integral part of WRP preservation, restoration and enhancement activities.

CHAPTER II. QUANTIFIABLE RECOVERY OBJECTIVES

A. Background

The SAP recognized the need for establishing quantifiable recovery objectives in the course of discussion of the WRP Regional Strategy. This document states that the long-term vision of the WRP is to "reestablish a mosaic of fully-functioning wetland systems with a diversity of habitat types and connections to the upland environment that preserves and recovers self-sustaining populations of species" (WRP 2001). To accomplish this vision, the six programmatic goals establish the intent to:

1. Preserve and restore coastal wetlands;
2. Preserve and restore stream corridors and isolated wetlands in coastal watersheds;
3. Recover native habitat and species diversity;
4. Integrate wetlands recovery with other public objectives;
5. Promote education and compatible access related to coastal wetlands and watersheds; and
6. Advance the science of wetland restoration and management in southern California.

These programmatic goals define the primary actions (preservation and restoration) and targets of these actions (wetland ecosystems), define the geographic scope (southern California coastal watersheds), and emphasize habitat and species diversity. They also establish ancillary goals that provide additional benefits to the public including improved water quality, storm flow management, education and public access, and a better understanding of wetland restoration and management in southern California.

Although the vision statement and six goals establish clear guidelines for WRP programmatic activities, there is a need to better articulate the major elements of wetland ecosystem structure and function that must be recovered in order to ultimately achieve the Regional Strategy goals. Articulating these elements establishes a more direct connection between management actions and the effects of those actions on the wetland ecosystem, and facilitates a science-based evaluation of WRP recovery efforts.

The term "recovery" as used in this document reflects two major concepts. First, "recovery" refers to a response by the wetland ecosystem to WRP restoration and enhancement activities. The second element of "recovery" is defined by the resilience of a wetland ecosystem to the natural and anthropogenic forces that affect its ambient condition of the resource. Watershed anthropogenic stressors including non-point sources of contaminants, importation of freshwater, increase of impervious surface area in the watershed, introduction of non-indigenous species, and development of adjacent upland buffers can adversely impact the condition of the resource, despite WRP efforts. Disturbances due to climatic variability such as El Niño-related rain events or processes resulting from global change such as sea-level rise can result in decreased acreage of coastal wetlands or degradation in the condition of riparian zones. The ability of a wetland to recover from natural catastrophic events often depends upon the degree to which its structure and function have been impaired by anthropogenic stressors. Coastal wetlands have the ability to migrate landward over time, but only if adjacent upland buffers have not been converted to urban land uses. A riparian zone is more susceptible to extreme flooding events when a greater percentage of its watershed has been converted to impervious surface (Booth and Reinelt 1993). However, we must recognize the existence of other forces, natural and anthropogenic, which occur within a watershed and affect the condition of wetland resources. Recovery must be evaluated not only in terms of the impact on WRP activities, but also by assessing effect of watershed stressors on the resource condition.

B. Importance of Habitat Type in Setting Recovery Objectives

Habitat is a collective term for the resources required by a species for its survival and reproduction -- the place where a species can be found (Odum 1993). Habitat includes not only the biological components such as the vegetation and fauna that serve as food sources and cover, but also the geologic, hydrologic and geomorphic processes that serve as the foundation for the biotic interactions. Recovery of a particular habitat requires enhancement or restoration of the various natural processes, structure, and functions that led to the development of that habitat.

The concept of "habitat type" is borne of the idea that many species share a common set of physical and biological resource requirements. "Salt marsh" and "mudflat" are two commonly used terms used to imply wetland habitat types. Wetland classification systems such as that of Cowardin et al. (1979) or Ferren et al. (1996) are more formal means of defining habitat types, with varying levels of detail. Although this document does not define the habitat types of southern California wetland ecosystems, it is important to understand how this concept can be used to develop quantifiable recovery objectives for the region.

There are two possible paradigms that could be used in developing the framework for quantifiable recovery objectives: 1) a species approach, in which restoration goals are based on providing optimal habitat for particular species of interest (i.e. dominant, threatened or endangered species), or 2) a habitat type approach, in which the objective is to restore habitat diversity with the assumption that high species diversity would be an expected outcome of the appropriate mix of wetland habitats in southern California. Restoration plans that are driven by the objective of creating habitat for a particular species can result in wetlands with a habitat type that may not support other important functions or is inappropriate given the landscape setting and hydrogeomorphic features of the site. For this reason, we strongly advocate the habitat type approach, with the underlying philosophy that the ecosystem as a whole is best recovered by approximating as close as possible the historical distribution of habitat types restored in their appropriate geographic or landscape setting. Emphasis should be placed on preserving and restoring habitat types that have experienced the greatest loss, while still retaining special consideration for threatened and endangered species. The SAP advocates this philosophy with the realistic understanding that, given the constraints imposed by an urbanized landscape, it may be difficult to completely replicate the condition and relative distribution of historic habitats.

The habitat type approach was used to develop a general set of quantifiable recovery objectives detailed below. The intent is that these objectives be applicable to all classes of southern California wetland (Cowardin et al. 1979; Ferren et al. 1996) and their adjacent and transitional habitats (e.g. riparian) habitats, that they have a direct link to management or restoration actions, and that they can be translated to indicators or measures to evaluate the success of those actions.

C. Linking Recovery Objectives to Management Actions

There are five major quantifiable recovery objectives:

1. Maintain existing and increase wetland ecosystem acreage
2. Recover habitat diversity to reflect historic distribution
3. Restore physical processes Recover biological structure and function
5. Recover landscape elements of ecosystem structure

These objectives describe the major elements of wetland structure and function that are critical to achieving the recovery of a mosaic of fully-functioning wetland ecosystems. They are also directly linked to the management, restoration, or enhancement activities undertaken to achieve these objectives (Table 1). These linkages are illustrated in Fig. 2a. It is important to recognize that these objectives operate within a hierarchy of spatial scales that range from the individual site to the drainage basin, watershed, and region (Fig. 2a-b). The effectiveness of these management actions and the progress of wetland ecosystem recovery can therefore be evaluated at several scales, depending on the management question. Separate indicators or different scaling of indicators may be necessary at these different spatial scales. Some objectives, such as the increase of wetland acreage restored or under protection, can be evaluated both for a particular site as well as for the watershed or region as a whole. Other elements, such as connectivity or habitat support for migratory birds, can only be assessed at the landscape scale.

Fig. 2a. Schematic of linkage between WRP vision statement, quantifiable recovery objectives, management or restoration actions, and feedback with monitoring.

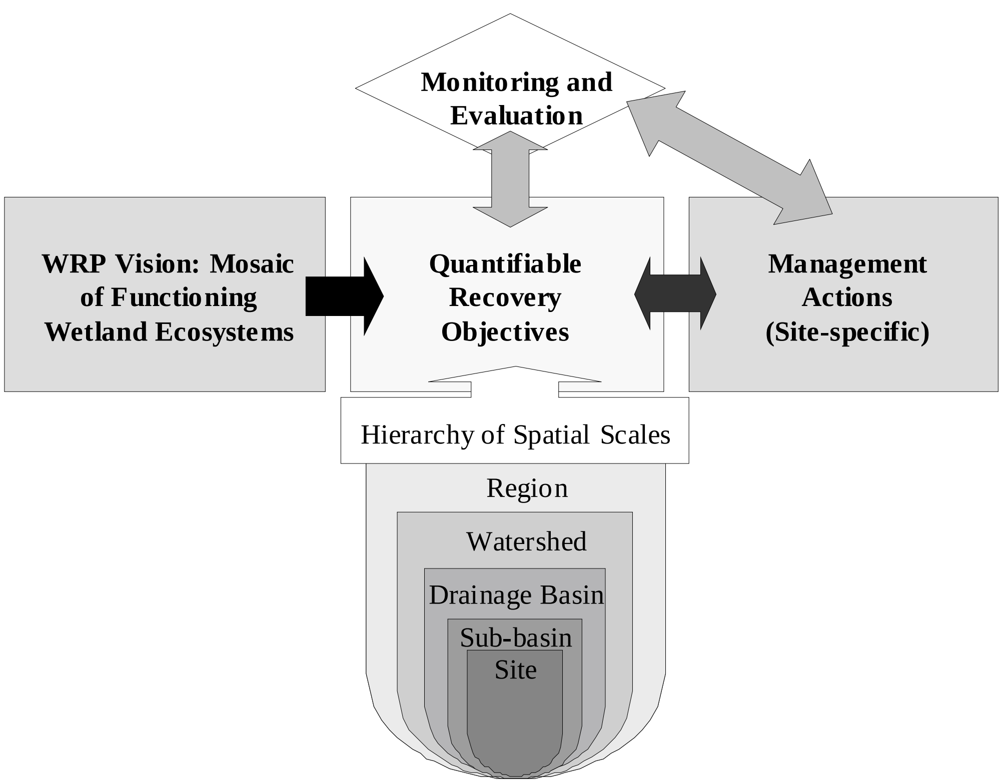
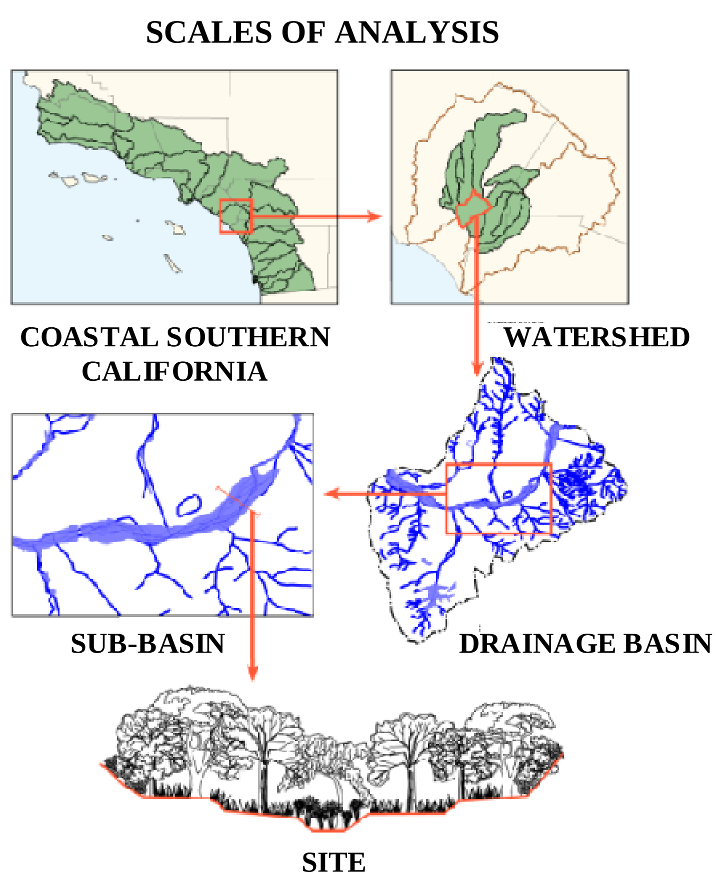


Table 1. General categories and specific examples of management activities

General Management Activity	Specific Examples
Acquire land	Acquire conservation easements
	Acquire fee title to property
Manage hydrology	Reconnect stream channel with floodplain
	Increase tidal prism
Manage physical structure of the site	Increase density of tidal channels
	Remove or set back levees
Manage biota	Remove exotic species
	Replant native vegetation
Control contaminant sources	Treat or divert wet- and dry-weather urban runoff
	Remove contaminated wetland sediments

Fig. 2b. Diagram depicting the hierarchy of spatial scales in which management actions and recovery progress must be evaluated.



D. Explanation of Quantifiable Recovery Objectives

1. Maintain Existing and Increase Wetland Ecosystem Acreage

State-wide, California has lost approximately 91% of its wetlands, reducing the total surface area occupied by wetlands from 5% of the land to less than one-half of one percent (Dahl 1990). 75% of the approximately 53,000 acres of southern California wetlands have been destroyed (CDPR1988), especially coastal salt marshes (CCC 1989; CDFG 1983; Zedler et al. 1992), riparian corridors (Faber et al. 1989), and vernal pools (Zedler 1987). A report of the California Coastal Zone Conservation Commission in 1975 estimated that 62% of the remaining wetland acreage has been "severely damaged;" given the population explosion in southern California in the past 25 years, this percentage is now likely to be much higher.

The loss of wetlands in southern California, along with degradation of those remaining, has greatly reduced the natural functions for which wetlands are so highly valued. These functions include 1) habitat to support native species biodiversity, 2) food chain support, 3) hydrological processes, including storm flow management and surface water storage and groundwater recharge, 4) sediment yield, transport and storage processes, and 5) biogeochemical functions important for water quality, including the cycling of organic matter and nutrients, and the trapping and transformation of pollutants (Mitsch and Gosselink 1986). In addition to loss of regional biodiversity, the alteration of hydrology and deterioration of water quality severely impacts the quality of one of southern California's most valuable resources: its coastal waters. The loss of wetlands in coastal watersheds has contributed to deteriorating water quality in beaches, coastal lagoons, bays, and the marine environment.

The restoration of these natural functions can be accomplished on a meaningful scale only if existing wetland ecosystem acreage in southern California is maintained and new acreage is created. There are two major types of actions that the WRP and its partners fund to maintain existing acreage and increase acreage: restoration and preservation. *Restoration*, in particular the re-creation of wetland habitat from other land uses, is the major means of increasing acreage. Excavation of fill dirt in what is now currently upland habitat in both Tijuana Estuary and San Dieguito Lagoon in San Diego County, and reclamation of riparian habitat converted to agricultural land along the Ventura River in Ventura County are among the several projects planned to increase wetland acreage.

Preservation includes the acquisition of fee title or conservation easements in wetlands, riparian areas, and associated upland habitats that are presently in private ownership and therefore not subject to conservation guarantees. Some of these parcels may be in pristine condition, while others may be degraded and require further enhancement to lift their functional capacity. The preservation of parcels such as the Huntington Beach wetlands in Orange County, Otay Mesa vernal pools complex in San Diego, or the Cold Creek riparian corridor and adjacent uplands reduces the risk of future loss and threat of degradation to wetland resources. The recent Supreme Court decision on the case of *Solid Waste Agencies of Northern Cook County v. U.S. Army Corps of Engineers* (known as the SWANCC decision) determined that regulation of wetlands beyond navigable waterways is the province of the state and local governments, thereby reducing the protection of Section 404 of the Clean Water Act for important isolated wetlands such as vernal pools and ponds, and intermittent and interrupted streams (Ruffolo 2002). The SAP highly recommends that the WRP continue to place a strong emphasis on non-regulatory means of preserving these under-protected wetlands and their transitional and upland habitats such as acquisition of fee titles and conservation easements. In addition the State of California should strongly consider the development of a statewide wetlands regulatory program that establishes clear protections for all wetlands and their transitional (riparian) and adjacent upland habitats.

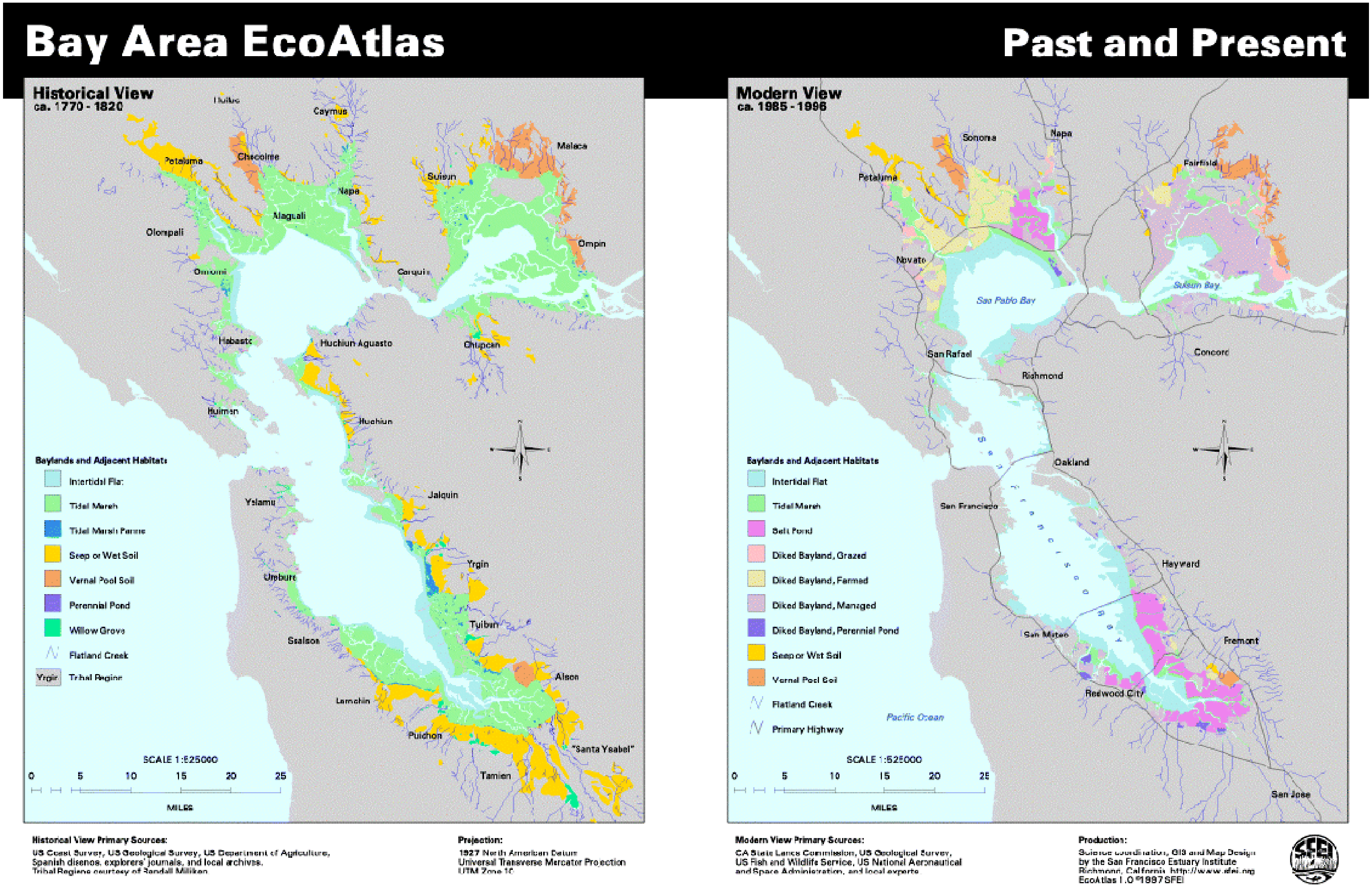
2. Recover Diversity of Habitat Types to Reflect Historical Distribution

The southern California coastal region is characterized by a great diversity in climate, topography, geology, and hydrology. The variability of these basic hydrogeomorphic elements, and the processes that are active within them, are responsible for the richness of wetland ecosystem types and the habitats found within them (Ferren et al. 1996). Southern California wetland ecosystems occur in a multitude of geomorphic settings, including floodplains, estuarine and lacustrine fringes, topographic depressions, slopes, and mineral or organic soil flats. The wetland's position in the landscape influences the physical processes that drive the hydrology, geomorphology, and chemical properties, and control the structure and function of the biotic community found there. Wetland habitat types cannot be restored if the underlying physical processes that originally resulted in development of that particular habitat are not reestablished. In order for restored or created wetland habitat types to be self-sustaining, they must be appropriately sited in the watershed.

The flora and fauna endemic to these wetlands have evolved life cycles that are dependent on the spatial structure, interspersion and connectivity of wetland and upland habitat types in the landscape. Thus, the recovery of high regional biodiversity of wetland-dependent species in southern California demands the restoration of the historical distribution of wetland habitat types and the physical processes that underlie them. Attention must also be paid to the spatial organization and distribution of these habitat types on scales from within the individual site to drainage basin, watershed, and sub-region.

European influence and modern development have considerably changed the southern Californian landscape and dramatically changed the spatial distribution as well as the profile of wetland habitat types (Ferren 1985; Macdonald et al. 1990). The extensive expansion of agriculture, urbanization and exploitation of natural resources have resulted in the filling, diking and fragmenting of wetlands, alteration of natural hydrology, diversion and pollution of water sources, and the extraction or harvesting of physical and biological resources. While some regional documentation of coastal resources is available from the late 19th and early 20th centuries, the detail in these information sources is limited. Despite this limitation, it is possible, using a combination of historical and present-day data and best scientific judgment, to formulate the historical profile of wetland habitat types and their spatial distribution. This historical picture can help to create a common vision for ecosystem restoration, and help to inform the process of setting regional habitat acreage targets (Gwin et al. 1999). Historical data assembled in the San Francisco Bay EcoAltas and used in the formulation of habitat goals are an excellent example of this concept (Goals Project 1999). Fig. 3 illustrates the comparison of historical versus

Figure 3. Comparison of historical (1770-1820) versus present-day (1965-1995) wetland acreage by habitat type in San Francisco Bay (diagram courtesy of San Francisco Estuary Institute, 2002)



present-day wetland acreage by habitat type in San Francisco Bay. Many of the historical sources used in the San Francisco Bay EcoAltas are also available for southern California. While some of this information has been drawn upon to characterize historic condition and habitat type distribution of particular wetland systems such as the Los Angeles River basin (Fig. 4; Rairdan 1998) or the Greater San Diego Bay Complex (Table 2; Macdonald et al. 1990), a complete regional picture of historical wetland distribution has not yet been assembled.

Table 2. Approximate Habitat Changes in the Greater San Diego Bay Complex[a]: 1856 – 1980s

Habitat	1856[b]	1902[c]	1984-87[d]	% Difference[e]
Salt ponds (diked)	0	24	1,252	----
Intertidal salt marsh	4,760	4,698	630	- 87 %
Intertidal sand/mudflats	6,186	5,641	1,005	- 84 %
Shallow subtidal:				
0 – 6 ft below MLLW	7,672	8,455	2,404	-69%
6 – 18 ft below MLLW	2,341	2,148	5,727	+ 136 %
Deeper subtidal:				
> 18 ft below MLLW	2,286	2,536	4,268	+ 87 %
Total Acreage	23,335	23,502	15,286	- 35 %

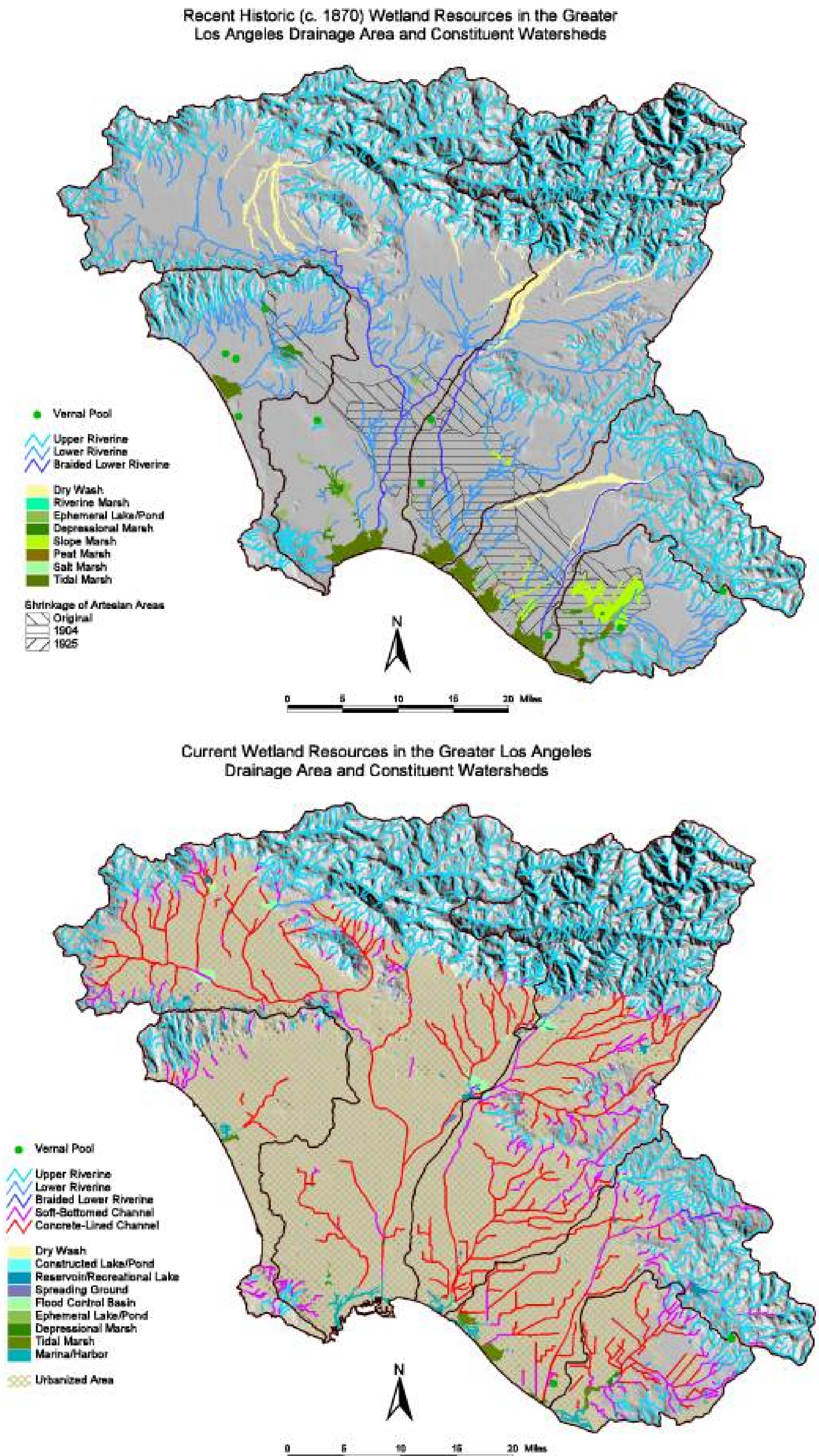
Notes: a. Includes Mission Bay, San Diego Bay, and Tijuana River Estuary
b. Uses 1856 Mission Bay data, except for intertidal salt marsh
c. Uses 1902 Tijuana River Estuary Data
d. Uses 1984 San Diego Bay, 1985 Tijuana River Estuary, and 1987 Mission Bay data (includes San Diego River Flood Control Channel).
e. Percentage loss or gain, 1856 through 1984-1987

Thus, the intent to "recover habitat diversity to reflect historical distribution," stated as a recovery objective, represents the philosophy to use historical data to the extent practicable to prioritize restoration of habitat types that have experienced the greatest loss. The SAP advocates the initiation of a project to document the historical acreage and distribution of southern California wetland habitat types. These data should be used to inform decisions on selecting priority habitat types for restoration, as well as to establish one benchmark to evaluate the long-term progress of the WRP regional wetland recovery efforts. As stated earlier, evaluation of this objective would take into account the constraints that result from undertaking restoration in a highly urbanized landscape. In many cases, several of the physical processes that are key to restoring a particular habitat type have been greatly modified. Examples include the perennial flow of imported freshwater (i.e. urban runoff) into salt marsh systems such as in the Ballona wetlands, or the hardscaping of stream bottoms, banks and adjacent land in the Los Angeles River. True restoration of the physical processes in these systems can only occur at considerable expense. WRP regional habitat acreage goals must realistically take these constraints into account (see Section III.A)

3. Recover Physical Processes

There are three major physical functions that control the physical processes that occur in wetlands. These are hydrology, sediment transport, and biogeochemistry. Each of these functions, and their principle attributes will be discussed in turn.

Figure 4. Map of historical (c. 1870) and present-day (1998) wetland resources in the Greater Los Angeles drainage area (courtesy of Rairdan 1998)



a. Hydrologic Functions

Hydrology is the primary driving force controlling wetland structure and function. For this reason, wetlands or riparian areas that have been hydrologically modified often have immediate visible impacts on their geomorphology (e.g. channel dimensions) and biological function (e.g. species composition, vertical structure, non-indigenous species invasions). Hydrological processes also affect the residence time of contaminants as they are transported through the system. Hydraulic residence time has a major impact on the biogeochemical rates of uptake and transformation in the wetland, processes that are very important in improving water quality.

There are generally two functions of hydrology in wetland ecosystems: energy dissipation and surface and sub-surface water storage and exchange (Brinson et al. 1995). In coastal southern California these processes operate on multiple spatial scales ranging from within a particular site or stream reach, to sub-basins and the entire watershed (Fig. 2a). An evaluation of recovery must address the processes operating at all of these scales. Elements of these processes are summarized below.

i. Energy dissipation

Energy dissipation is the reduction of the kinetic energy of water. Wetland ecosystems dissipate energy through rugged surface topography, channel form and roughness, sediment texture, and vegetation (Mitsch and Gosselink 1986). Steep headwater mountain streams dissipate energy with greater roughness due to irregular channel morphology, coarse bed materials including large boulders and woody debris. Towards the coastal zone (where generally channel slopes are less steep), floodplains, terraces, and other off-channel locations also provide additional area over which rapidly flowing water can spread. This attribute is particularly important in dissipating the energy from storm flows in riverine wetlands and adjacent riparian areas and in providing a protective buffer for shoreline development from storm or tidal surges. Hydrological modifications such as hardscaping stream channel bottoms or isolating river channels from their floodplains or downstream estuarine wetlands greatly reduces the capacity for energy dissipation during storms.

ii. Surface and sub-surface water storage and exchange

Many wetland ecosystems provide flow exchange and storage between surface and groundwater sources, a process that can occur locally between the water body and a shallow aquifer, or as an exchange with a deeper aquifer that crosses watershed boundaries (Tobias et al. 2001). In semi-arid environments like southern California, this is a particularly important function. Water may be stored above the surface, as shallow subsurface water in sediment porewaters or soil moisture in the saturated zone, or as recharge to groundwater. The capacity of a wetland and adjacent riparian area to perform this function depends on the surface sediment as well as the underlying geologic material. Hydrological modifications such as freshwater diversions, hardscaping stream channel bottoms or isolating river channels from their floodplains or downstream estuarine wetlands greatly reduces the capacity for surface and sub-surface water storage and exchange.

b. Sediment Yield, Transport, and Storage Processes

Wetland ecosystems can variably deposit, store, remobilize and transport sediment via surface waters. The characteristics of sediment deposition, storage, remobilization and transport are determined by the timing, quantity and duration of hydrogeomorphic processes acting on the drainage basin. The relative importance of these factors and their effects on channel morphology and biotic community varies depending on landscape position (and therefore wetland class). Therefore, riverine wetlands have very different sedimentary processes than do estuarine or lacustrine wetlands. Modifications in hydrology (i.e. timing, magnitude, or duration of flow) or changes in sediment yield in the watershed can greatly impact wetlands, causing shifts in habitat types either by infilling from accelerated sediment delivery or wetland loss from sediment deprivation. There are several aspects of sediment yield, transport, and storage processes that should be considered the recovery of physical processes. These are discussed below:

i. Sediment Yield

Sediment yield to wetlands and adjacent riparian areas is a function of sediment sources, watershed position, hydrologic conditions, and the type of sediment being transported. Sediment from source areas is transported down watershed through a number of processes including: mass movement (the gravity-controlled movement of soil and rock downslope); hillslope processes (including sheetwash erosion, rilling, and dry ravel), and fluvial processes occurring in stream channels (Collins and Dunne 1990). Dominant sediment source areas and transport processes often have recognizable characteristics within a watershed. For example, landslides, may yield sediments with a grain size distribution similar to hillslope materials while storm-generated runoff may typically result in clay, silt, and sand sized sediment transport and delivery. The post-fire erosion environment is particularly important in southern California, whereby erosion rates may increase tremendously during the 3-5 years following a fire depending upon rainfall conditions. Many of the alluvial valleys of coastal southern California have overbank deposits, or older Pleistocene-formed stream terraces, which can either store upstream materials or contribute sediments towards downstream yields when a channel system is undergoing systematic adjustment. Actively incising streams, either caused by natural geologic processes towards equilibrium or due to anthropogenic forces in the watershed will also shed increased levels of sediment downstream (Madej 1982).

In all cases, the quality of the sediment supplied (grain size, texture, and chemical properties) is a function of the geology of the source material, the type of process, and landscape position. Anthropogenic activities can affect the rate at which these processes yield sediments to the drainage network. Urbanization increases the impervious area in a watershed, resulting in reduced infiltration and increased runoff response to rainfall. Urbanization thus often results in greater runoff volumes, and higher peak flow rates.

Depending upon sediment supply conditions, increased runoff and streamflow energy due to urbanization often leads to increased sediment yields, particularly during the construction build-out phase within a watershed. Agriculture and development of roads are also increase sediment yield (Reid and Dunne 1984). In the post development scenario, watershed sediment sources are often reduced or structurally disconnected from passing materials downstream coastward.

Storage of sediment behind dams along many of the coastal drainages of southern California has prevented beach renourishment downstream.

As a result of increased development and disturbance in the watershed, sedimentation rates in coastal wetlands have substantially increased. Onuf (1987) showed a 40% decrease in the volume of Mugu Lagoon due to anthropogenic increases in sediment input. Calhoon et al.(1996) measured extremely high rates of sediment accretion (up to 8 cm yr-1) from storms in the early 1990s. These rates are much greater than long-term rates and likely contribute to habitat conversion with the estuary (Mudie and Byrne 1980; Weis et al. 2001).

ii. Transport, Deposition and Storage of Sediments

The transport, deposition and storage of sediments in stream, rivers and estuaries is highly variable, both spatially and temporally. It is the interaction of hydrologic processes, landscape position, and sediment yield to the system that control the transport, deposition, and storage of sediments. This in turn controls the physical structure of the channel, banks, and floodplain, and elevation of wetland sediments – a critical aspect of habitat.

As rivers undergo a downstream reduction in gradient, the energy to transport sediments decrease, and the coarsest portion of the bedload and suspended load are deposited (Collins and Dunne 1990). This downstream reduction in channel gradient is associated with downstream reduction in grain size for deposited materials. Sediment deposits (stored within an integrated channel, floodplain, and terrace system) may rest in place for periods ranging from a year, to decades, to even centuries, depending upon the frequency and magnitude of storm events required to initiate transport.

Anthropogenic activities in watersheds, and modifications to rivers, lagoons, and estuaries can cause a major change in the transport, deposition and storage of sediments throughout the drainage network (Reid and Dunne 1984). Structures such as Arizona crossings, tide gates, drop structures, dams, and other types of impoundments change channel gradients and cause changes in the sediment transport regime. The drainage network downstream of an impoundment is often starved for sediments, a major problem in maintaining a steady supply of sand to beaches. In estuaries such as the Buena Vista Lagoon in San Diego County or Mugu Lagoon in Ventura County, the presence of berms, tide gates and culverts dampens tidal flow exchange and limits the seaward transport of sediments (Onuf 1987). This causes the system to aggrade, becoming progressively shallower. As in Tijuana Estuary, coastal wetlands aggrade when watershed anthropogenic activities cause major changes in sediment yield, resulting in increased erosion, net deposition downstream, and major loss of habitat (Calhoon et al. 1996).

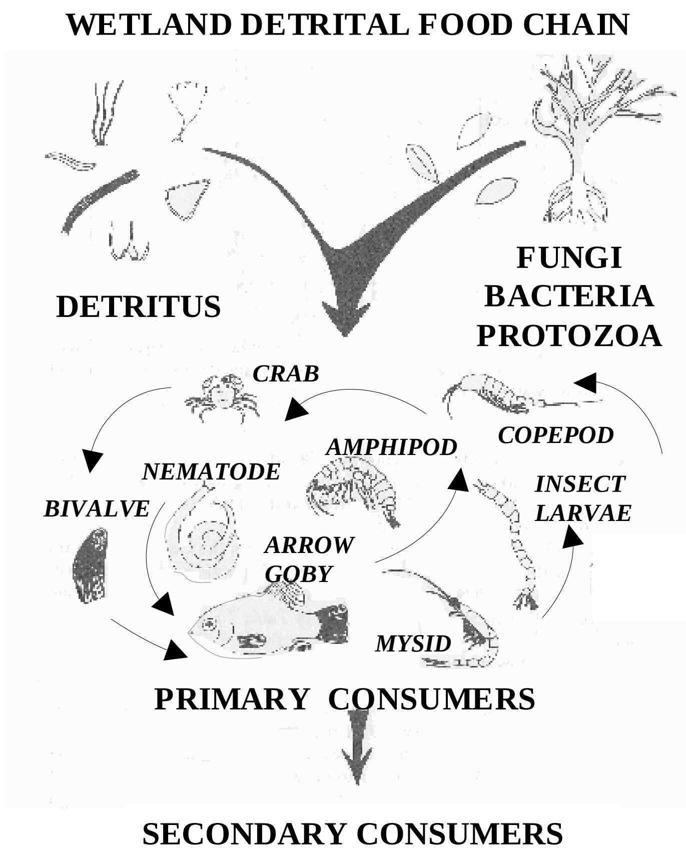
c. Biogeochemical Functions

The biogeochemical functions of wetlands are an interdependent array of mechanisms that control biological productivity and the quality of habitat provided by a wetland, as well as water quality benefits it provides. The processes of chemical transformations, adsorption and desorption, flocculation, precipitation, as well as the biological uptake, transformation, and release of elements and compounds make up just some of the biogeochemical functions exhibited by wetlands (Mitsch and Gosselink 1986). Together, these biogeochemical functions control:

i. Cycling and export of detrital organic matter

The cycling and export of organic matter in the form of detritus is an important factor in maintaining high biological productivity and food chain support within a wetland and adjacent habitats (Day 1989). Leaf and tree litter, decaying algae, dead animal tissue and feces provide fuel for growth of fungi, bacteria and protozoa and are consumed directly by some invertebrates and fishes. As organic matter decomposes, nutrients are released, providing the building blocks for the growth of plants and algae. Consumption of microorganisms, plants and algae by primary and secondary consumers organisms transfers the organic matter up the food chain (Fig. 5). Wetlands sediments are a good example of the importance of detritus in supporting biological productivity. The incorporation of detritus into the wetland sediment provides organic carbon, nutrients and texture critical for the establishment of healthy plant communities. Wetland sediments with low organic carbon or nitrogen content retard development of plants with appropriate biomass, density, and vertical structure, and have been sited as reasons for which projects haven failed to meet habitat restoration objectives (Zedler 1996b).

Figure 5. Schematic of a wetland detrital food chain showing transfer of organic matter and energy through primary and secondary consumers (Day 1989)



ii. Cycling of macro and micro-nutrients

Nutrients are the building blocks for the growth of plants and algae in wetlands. The quantities available and how they cycle restricts to a great degree the kind of biotic communities found there. Plant macronutrients including nitrogen, phosphorus, and potassium are required in major quantities for growth. Micronutrients such as including iron, manganese, molybdenum, cobalt, and copper are needed in very small quantities and can be toxic in larger doses. Many vitamins and most minerals are also critical micronutrients for wetland fauna, and needed in small quantities to maintain function because the animal itself cannot synthesize them. The cycling of these macro- and micronutrients in wetland ecosystems represents an important set of biogeochemical processes critical to the maintenance of biological function. Many aquatic biota in west coast streams and estuaries have evolved to thrive in conditions produced by low macronutrient concentrations (Kamer et al. 2001). An increase in the quantity of nutrients available often causes increases in algal biomass and large fluctuations in dissolved oxygen in surface waters and sediments. These changes over time can cause a shift in community composition, particularly in invertebrates and periphyton, and an overall reduction in biodiversity (Childers et al. 2001).

iii. Uptake, sequestration, and transformation and release of contaminants

Wetland ecosystems are highly valued for their ability to take up, sequester and transform anthropogenic sources of contaminants. These complex interactions are responsible for the water quality cleansing functions of wetlands. Bacteria mediate a whole host of reactions, including the removal excess inorganic nutrients or converting them to a less biologically reactive form and the sequestration or transformation of heavy and trace metals so that they are effectively removed from the surface waters (Gambrell 1994). The degree to which these functions enhance water quality is dependent on the wetland’s position in the landscape, the geology of the region, hydrologic regime, the chemistry of the water and soils, and the flora and fauna that inhabit the wetlands. The benefits provided by a wetland to a watershed often begin to deteriorate when the level of anthropogenic disturbance (i.e. level of contamination, changes in hydrology) exceeds the system’s capacity for resilience. After this point, biogeochemical functions decline as the disturbance affects permanent changes in biotic community composition and the biological functions so critical in controlling the biogeochemistry (Childers et al. 2001). Thus large-scale changes in watershed hydrology, land use, and dominant biotic communities are often visible in the alteration of biogeochemical functions at a particular site.

4. Recover Biological Structure and Function

The biological structure and functions found in wetland ecosystem are the result of a complex set of interactions between the physical processes that provide the foundation for habitat and the community of biota that utilize and modify the habitat. The opportunity to see this mosaic of flora and fauna in their natural state is one of the values that humans prize in wetlands. Also greatly valued, these organisms are responsible for the important biogeochemical cycles that result in improvements to water quality.

Anthropogenic stressors can alter the biological structure and function in wetland ecosystems. An important part of evaluating restoration or recovery of a system is to evaluate the structural and functional integrity of its biological community. As with the physical processes, evaluation of this objective must take in account the variety of spatial scales, site-specific to drainage basin, watershed and region, that play a role in how the biota interact and function. These spatial scales are inherent in the important elements of biological structure and function, outlined below:

a. Native Species Biodiversity

The number of species, often referred to as species richness, is the oldest concept of biological diversity (Krebs 1999). While diversity is also discussed at the level of genetics, habitats (see Objective 2 in Section II.D.2), and ecosystems, this element of biological structure and function is centered on the diversity of species – within a site, between sites of similar habitat types, and for the region as a whole. In addition to species richness, another important element of biodiversity is that of heterogeneity, or the relative abundance of species. Communities are considered to be more diverse when there are more species and when the species approach equal abundance (Krebs 1999).

The ability to support characteristic native plant, invertebrate, and vertebrate biodiversity is one of the most basic attributes used to assess the level of biological functioning (Zedler 1996b). Higher native plant diversity improved the development of function in restored salt marsh including a more complex canopy (Keer and Zedler 2002), great biomass accumulation, and nitrogen retention (Zedler et al. 2001). Failure to maintain biodiversity can occur when the wetland habitat is disturbed by any number of anthropogenic and natural stressors (i.e. contaminants, hydrological modifications, invasions by exotic species, catastrophic flooding, drought). Although populations of native species undergo natural fluctuations in abundance, long-term declines in native species biodiversity and changes in relative abundance are indicative of the loss of biological function. The objective of maintaining high biodiversity of native species should be assessed by long-term changes in the populations of not only of threatened and endangered species but also keystone or indicator species characteristic of wetland habitat types. These attributes are important to monitor within and among wetland ecosystem habitat types, as well as for the southern California region as a whole.

Invasion by exotic species is a serious threat to the maintenance of regional diversity of native species in southern California wetlands (Zedler 1996b). Exotic plant species can invade wetlands if the substrate is disturbed or if hydrological modifications cause a change in habitat type or soil salinity. Many mediterrean exotic plants thrive under low salinity conditions and do best in areas with excess urban runoff (Callaway and Zedler 1998; Kuhn and Zedler 1997). An alien plant species can be a particularly successful invader if it has high seed production, high germination rates, and the ability to spread vegetatively (Zedler 1996). Contaminated water sources such as urban runoff or ship ballast water are often excellent vectors for exotic species.

b. Maintenance of Spatial Structure and Distribution of Plant Associations, Aquatic and Terrestrial Invertebrates and Vertebrates

Biological communities have structure, not only in terms of species richness and abundance, but also the spatial and temporal patterns of floral and faunal distributions in the habitat. For plants, structure can imply the plant associations, growth form (such as plant or canopy height), and vertical stratification (as is found with trees, shrubs and herbaceous cover). Canopy architecture has been shown to be an important attribute of habitat for several bird species. The presence of tall cordgrass in the low salt marsh habitat has been shown to be important for nesting of the light-footed clapper rail (Zedler 1993). The height and cover of glasswort are important attributes of the clapper rails refuge during high tide (Zedler 1996b). Pickleweed branches of sufficient height and strength are important to the endangered Belding's Savannah sparrow because the birds perch on the highest plants available to defend their territory (Powell 1993). For herbivores and carnivores, the proximity, diversity, and abundance of food sources, and the proximity and nature of refuge are important aspects of the spatial structure of habitat (Power and Rainy 2000).

c. Maintenance of Predicted Food Web Linkages and Trophic Levels

The transfer of energy as food through the different trophic levels is referred to the as the food web (Krebs 1999). Each of the trophic levels -- producers (green plants), primary consumers (herbivores), secondary consumers (carnivores, parasitoidal insects), tertiary consumers (higher carnivores) – can be further classified into *guilds*, which are groups of species exploiting a common resource base in a similar fashion (Root 1967). Within each of these trophic levels, the guilds of species play basic functional roles in the wetland biological community.

Recognition and monitoring of the trophic levels and guilds is an important element to evaluate the level of biological function of wetland ecosystems. For example, Kwak and Zedler (1997) found that intertidal macroalgae, marsh microalgae and *Spartina foliosa* served as an important food base for salt marsh invertebrates, fish, and the light-footed clapper rail. The loss of species (either locally or regionally) or reduction in a guild of species through habitat loss can radically change the flow of energy and materials through the food web, and reduce abundance of consumers (Meffe and Carroll 1997). The addition of exotic species can also change food web structures by occupying important niches in habitat previously utilized by native species. Replacement of these native species eliminates them as a food source, thus changing the food web structure and energy flow.

Changes in the abundance or biomass of a particular trophic level guild are also a critical factor affecting food web linkages and overall ecosystem health. As the lowest level in the food web, the production of plant and algal biomass is an important attribute controlling the structure of the food web. The standing biomass and annual production of vascular marsh plants and riparian trees, shrubs, and herbaceous plants are often used as a indicator of ecosystem health. Aquatic plant and algal productivity is also extremely important; Covin et al (1988) found that macroalgal production in southern California wetland surface waters was equal to that of vascular plants. Many aquatic plants and algae such as seagrasses, macroalgae, periphytic algae, and phytoplankton, are extremely susceptible to increases in nutrient loading, particularly from anthropogenic sources (Fong et al. 2001; Kamer et al. 2001). Nutrient inputs result in increases in algal biomass, often resulting in low oxygen events and fish and invertebrate die-offs.

5. Recover Landscape Elements of Ecosystem Structure

In general, landscapes are highly organized, interacting mosaics of terrestrial and aquatic habitat types with structure inherent on many spatial scales (Fig. 6a-b). Geomorphic position and the sum of tectonic, geomorphic, hydrologic, and geochemical processes acting on the landscape determine the unique assemblage of wetland, riparian, and upland habitat types found there. As mentioned in the previous section, flora and fauna endemic to southern California wetlands have evolved life cycles that are dependent on the complex mosaic of wetland and upland habitat types in the landscape (Ferren et al. 1996). Anthropogenic activities can disrupt the structural integrity of landscapes and can radically alter the movement of material and organisms across the landscape (Garder et al. 1993). A regional plan for the recovery of southern California wetland ecosystem must restore the structural components and processes operating at various spatial scales.

Figure 6a. Mosaic of habitat types within a riparian corridor (adapted from USDA 1998)

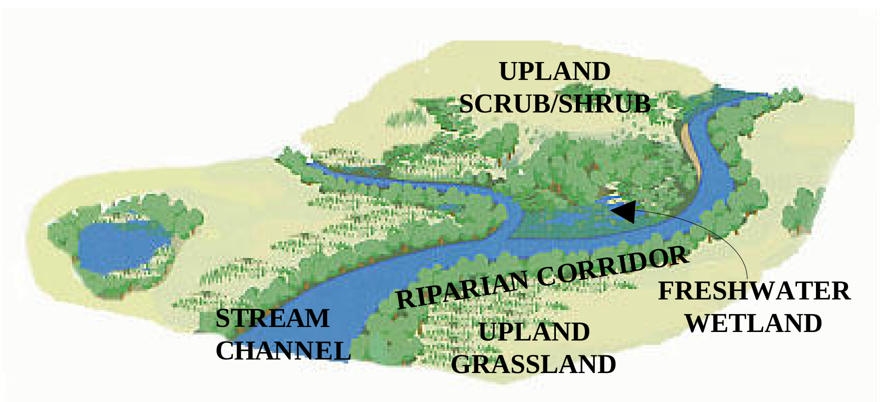
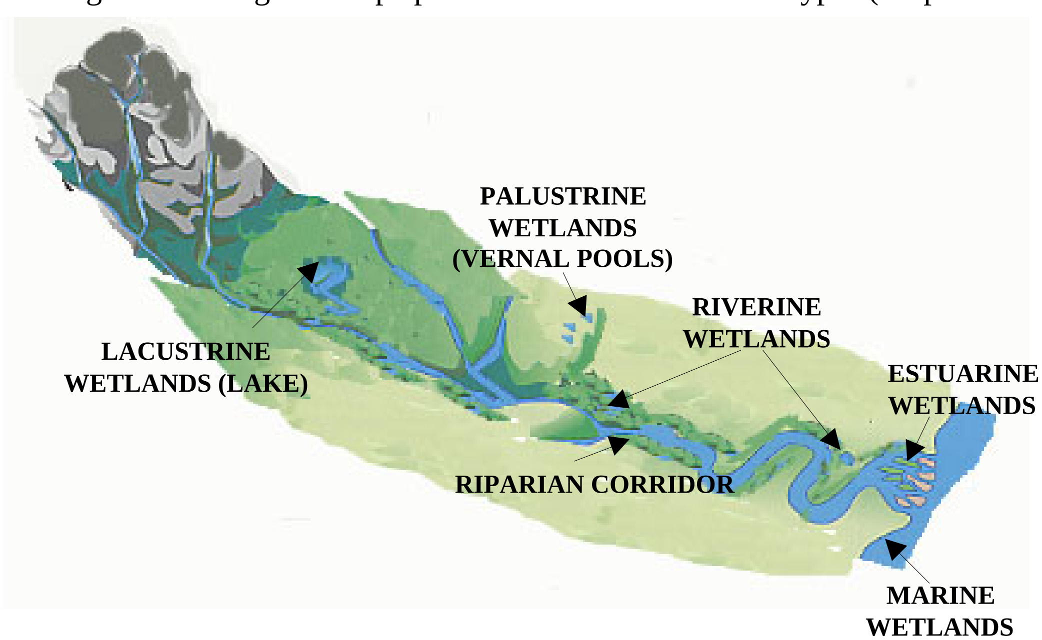


Figure 6b. Diagram showing landscape position of different wetland types (adapted from USDA 1998)



Important elements of ecosystem recovery that can be evaluated at the landscape scale include:

a. Habitat interspersion

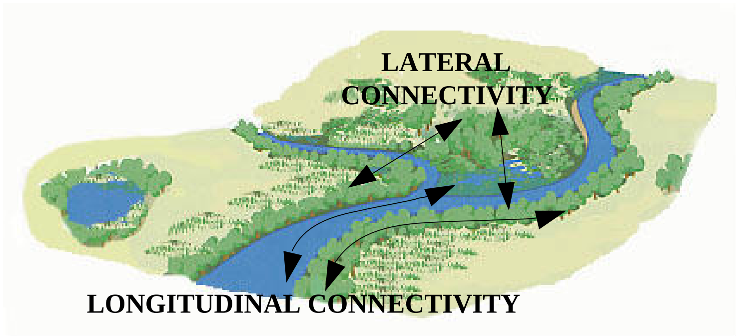
Aquatic, semi-aquatic, and terrestrial organisms utilize wetland ecosystem extensively to complete portions of their life cycles (i.e. reproduction, feeding, growth, refuge, etc.). The interspersion of habitats refers to the mixing of different habitat types in a patchwork pattern necessary for plants and animals to complete their life cycles (Fig. 6a-b). Monocultures typical in agriculture result in low or no habitat interspersion. Areas with high interspersion have habitat types with a high edge to area ratio, producing a multitude of ecotones that enhance biodiversity and biological function.

Adjacent uplands often include or once included grasslands, various types of coastal scrub (e.g., dune scrub, bluff scrub, delta scrub, coastal sage scrub, and chaparral) and oak woodland. Many plant and animal species depend on the continuity of the transition from wetland to upland to survive in an area. For example, edge-dependent species of southern California coastal wetlands include mammals (e.g., Salt Marsh Shrew, Southern California Salt Marsh Harvest Mouse), birds (e.g., the state-listed endangered Belding's Savannah Sparrow, which nests in salt marshes and also forages in adjacent uplands), plants (Salt Marsh Bird's Beak) and butterflies. An insect-pollinated annual, the Salt Marsh Bird's Beak relies primarily on bees for pollination. Development of adjacent upland areas may have greatly reduced foraging and nesting habitat for the pollinators, thus reducing the production of viable seeds in the bird's beak (Fink and Zedler 1991). The caterpillar of the Pygmy Blue Butterfly eat only marsh and edge species of plants belonging to the Spinach Family and the caterpillars of the Wandering Skipper eat only Saltgrass. Adults of both butterflies nectar mostly on summer and fall flowering plants belong to the Sunflower Family that occur in adjacent palustrine marshes (e.g., Western Goldenrod) and shrubs of coastal scrub, grassland, and dune habitats including Coast Golden Bush and Mock Heather. Because many native coastal butterflies are dependent on specific host plants, without an appropriate mix of native habitats that support native plant communities, these edge-dependent species are not likely to survive in wetland ecosystems.

b. Habitat connectivity

Connectivity refers to the connection between habitat types, allowing for flora and fauna to enter, utilize and leave the habitat via large, contiguous patches (Fig 7). These patches occur on a variety of spatial and temporal scales that vary as a function of each animal's perceptions (Wiens 1976; Wiens 1989). At high tide and during flood tides, estuarine birds such as the federally-listed, endangered Light-footed Clapper Rail move into uplands contiguous to salt marsh habitat and can hide from predators if sufficient and appropriate vegetation cover exits. Raptors such as the White-tailed Kite forage in upland grasslands, transitional wetlands, and high salt marsh habitats for small mammals such as the Southern California Salt Marsh Harvest Mouse that is confined to the edges of estuaries. Thus, connectivity from the perspective of salmonid fishes differs from that of large mammals, amphibians, or birds. Many wetland species such as fishes, reptiles and amphibians are not capable of migrating overland if the connectivity of the wetland habitat is obstructed. While many migratory or wetland-dependent birds have the capability of flying to other habitats, the regional patchwork and connectivity of wetlands become important for these species.

Figure 7. Diagram illustrating concept of lateral and longitudinal habitat connectivity (adapted from USDA 1998)



c. Regional water budget

Hydrology is one of the major controls on wetland ecosystem structure and function, and alteration of the region's water budget is one of the major constraints on restoring biological and physical functions to historic levels. Given the relatively arid climate of southern California, historical agricultural development and subsequent urbanization have required aggressive development of local surface and groundwater resources, and ultimately importation of water from outside the region. Local water withdrawals often lower streamside water tables cutting support for riparian vegetation and reducing dry-weather stream flow. Conversely, increased runoff from agricultural irrigation and urban impervious surfaces increases the frequency and height of channel-altering storm flows and often increases dry-weather flows. Since the geomorphology of stream channels is directly related to their flow, these broad changes in the regional water budget cause changes in stream structure and function (including controls on erosion and sediment transport). Similarly, since the native riparian and stream biota have evolved in concert with pre-disturbance flow regimes, alteration of these regimes can stress native plants and animals, increasing their susceptibility to competition and invasion from non-natives. The SAP recommends that the WRP prioritize projects that give the greatest functional lift or recovery to landscape hydrologic processes. Projects such as removal of dams or reduction in the quantity of imported freshwater are most likely to move the regional water budget towards its historic condition, and are therefore likely to have a far-reaching impact on the recovery of individual sites throughout the watershed.

d. Landscape hydrologic connectivity

Landscape hydrologic connectivity refers to continuity of exchange in three dimensions: 1) vertical connectivity between surface and sub-surface flows 2) longitudinal connectivity between the coastal ocean, estuaries, rivers and their upstream tributaries, and 3) lateral connectivity between wetland and associated transitional (riparian) or upland habitats. Hydrological modifications resulting from isolating of river channel from their floodplains, or which result in channel incising or infilling can disrupt the hydrologic connectivity, and negatively impact water quality and biotic community of that system. Historical data generally show a pattern of narrowing stream corridors and simplification of habitat types along southern California streams over time. Side channels and backwaters have been cut off or lost, wetland and riparian zone vegetation have been reduced to narrow fringes along stream channels. Reversing these trends will likely require first understanding, and then reestablishing or enhancing, the landscape hydrologic connectivity in all three dimensions.

CHAPTER III. DECISION SUPPORT FOR PRIORITIZING PRESERVATION AND RESTORATION ACTIVITIES

In recommending the five quantifiable recovery objectives, the SAP has identified the numerous elements of wetland ecosystem structure and function important to recovery. Prioritization is the process by which these objectives are translated into decisions by identifying ecological criteria that are most likely to result in improvements to the resource. Establishing priorities will the aid the WRP in reaching its recovery objectives and the long-term vision by maximizing the ecological and socio-economic benefits and probability of success. While the socio-economic benefits and cost are clearly an important consideration in prioritizing projects, the SAP does not currently represent the expertise required to advise the WRP on these issues. Therefore the discussion of decision support is limited to consideration of the ecological aspects of prioritization. Within the realm of WRP activities, the SAP recommends that prioritization take place on two different levels:

1. Setting habitat acreage targets for wetlands areas, and
2. Determining priority areas for preservation and restoration of riparian corridors in coastal watersheds.

A description of each of prioritization on each of these levels is given below.

A. Habitat Acreage Targets for Wetlands

Prioritizing the wetland classes and habitat types which have experienced the greatest loss for preservation and restoration is the means by which the WRP can achieve the second recovery objective: recovering regional habitat diversity to reflect the historical distribution of these habitats in the southern California landscape. The SAP recommends that the WRP develop a shared vision of the changes needed to improve the ecological functions and regional biodiversity of our region's wetlands. These targets can be developed by either or a combination of two principal strategies:

1. Comparison of historical versus present day wetland acreage by habitat type;
2. Developing the habitat requirements of common as well as threatened and endangered species using monitoring data and best professional judgment

Prioritization of preservation and restoration should driven by the objective of maximizing regional habitat diversity by restoring wetland habitat types to a ratio that approximates what was once found on the landscape (see Section II.D.2). Given the lack of detailed historical information, this strategy may produce limited results. However, an effort should be made to recover and document from various regional and local data sources the historical inventory of wetlands (see Section IV.C). To the extent necessary, this effort should be supplemented by evaluation of the habitat acreage needs of species representative of habitat types, as well as acreage required to support self-sustaining populations of threatened and endangered species. A combination of both strategies was successfully utilized in the S.F. Bay area to derive habitat acreage goals for tidal wetland preservation and restoration (Goals Project 1999).

Development and, particularly, urbanization of southern California coastal watersheds has made it unlikely that we can completely restore the wetland ecosystems to previous historic habitat types, surface area and level of functioning. In many cases, the technical and economic constraints imposed by urbanized land uses and altered physical processes force the restoration of habitat types that are not historic but rather reasonable and feasible. The SAP does not envision the recommended habitat acreage goals to be a rigid template, but rather a guide to focus on restoration priorities for the region as a whole.

Using either or a combination of the two strategies to set habitat acreage goals, two issues should be clear. First, the use of historical inventory data as well as the habitat needs of wetland dependent species relies a great deal on best scientific judgment based often on limited data sources. Second, it will be impossible to maximize habitat for all species. In the process of setting habitat acreage targets, the WRP will to need make some difficult policy decisions. Thus, the scientific knowledge and data that support the habitat acreage targets reflect the current state of understanding as well as conservation and restoration policies; it is anticipated that the habitat acreage targets should be revisited periodically in the future to reflect improved understanding of historical conditions and habitat requirements as well as practical experience in restoration.

Implementation of a habitat goals project is contingent on development of data sources for such an assessment. There are two major data sources: 1) historical inventory of wetland resources by habitat type, and 2) monitoring data used to develop habitat requirements of common as well as threatened and endangered species. The SAP recommends that the WRP support the development of a historical inventory, and catalog the availability of monitoring data that could be used to support the development of habitat acreage goals. This effort can be carried out concurrently with other ongoing efforts to develop a regional monitoring program and other decision support tools (see Section III.B and Section IV), and as such will also be complementary to those efforts as well.

B. Determining priority areas for preservation and restoration of riparian areas in coastal watersheds

Unlike coastal (tidal) wetlands where opportunities for restoration are limited, the preservation and restoration of riparian areas in the approximately 10,000 sq. miles of southern California coastal watersheds presents a formidable challenge for the WRP. To come up with a coherent regional strategy for project funding, the WRP must determine which riparian areas most merit preservation and restoration from an ecological perspective. This determination must be based primarily on a comparison of the ecological attributes of the an area, both in terms of how the riparian area might potentially contribute to the functioning of the watershed, as well as how watershed processes may affect the site's structure and function.

The SAP recommends that the WRP pursue the development of a decision support tool that will aid in identifying high priority riparian areas for preservation and restoration. It is our intent that the WRP Manager's Group will utilize the results of such an assessment to identify regional priorities to guide annual project selection. This tool also can be used by WRP County Task Forces as a preliminary screening tool to develop priorities for preservation and restoration as a part of the watershed management planning process.

1. Decision support tool project description

The NOAA Coastal Services Center has agreed to provide the WRP with the technical expertise to adapt the Spatial Wetlands Assessment for Management and Planning Model (SWAMP) as a decision support tool. The SAP has already begun to work with the WRP Managers group and County Task Forces to develop this tool. SWAMP, a geographic information system (GIS) based model, would be used to examine the ecological significance of a wetland to its watershed, as determined by the measured contributions of that wetland within three primary categories: habitat, hydrology, and biogeochemistry (water quality). One attractive feature of the conceptual framework behind SWAMP is that it allows the decision maker the flexibility to establish the rules and relative weights that determine the overall rating assessed for a riparian area. In the process of establishing rules and relative priorities, the WRP partners will engage in a public discussion of the attributes of riparian areas that are important in determining preservation and restoration potential, and the relative importance of each.

As envisioned by the SAP, the development of the decision support tool would undertake two principal tasks:

- Conduct a regional scale assessment of riparian zones to identify those areas with high preservation and restoration potential. This assessment would be performed for the southern California coastal watersheds that are entirely or partially contained within the five southernmost coastal counties (Fig 1).
- Incorporate assessment indicators into a user-friendly, GIS-based decision support tool. Features of this tool will allow the user to customize analyses to better reflect the local conditions of the resource in a watershed or group of watersheds.

The application of the SWAMP approach to southern California will address both preservation and restoration of riparian areas. Preservation priorities will be determined by assessing the ecological integrity of the riparian area, and examining the degree to which, by preserving the site, there is a decreased risk that the watershed and/or sub-region will experience a decline in the ecological functions and critical landscape linkages. Simply stated, the evaluation of preservation will assess potential future loss. Riparian areas that are most pristine and make major contributions to watershed ecological functions will be designated as priority for preservation. Restoration specifically refers to actions taken to obtain a former state of a natural condition. Restoration potential will be determined by assessing the ecological integrity of the riparian area and assessing potential future gains in functional capacity, as measured by a likely increase in the ecological functions and critical landscape linkages. Sites that rank high for restoration potential may be highly degraded, but if restored, might re-establish important corridors or linkages between previously isolated habitats or provide a significant contribution to watershed ecological services.

The SWAMP assessment of regional priorities will take advantage of other data sources collected through other local and regional conservation and habitat protection planning efforts such as the Orange County Special Area Management Plan (SAMP) or the San Diego Multiple Species Conservation Program (MSCP). The SWAMP assessment will also take into account the proximity of existing protected areas such as National Forest land, nature reserves, or other protected lands in the decision-making process.

2. SAP recommendations for implementation of decision support tool project

The SAP recommends that the WRP undertake a series of activities to facilitate the adaptation and implementation of SWAMP in southern California. These activities are described below:

a. Review and comment on SWAMP assessment framework

The NOAA CSC is in the process of collaborating with the SAP and additional experts to develop the SWAMP assessment framework. The SAP asks that each of the WRP partner agencies as well as County Task Force members review and provide feedback on the each of the three modules (habitat, hydrology, and biogeochemistry) that comprise the SWAMP assessment framework. This work will be conducted through December 2002.

b. Development of data layers to support SWAMP assessment

A preliminary review of data sources in southern California has revealed major gaps in mapping of land cover and riparian zone vegetation needed to complete this analysis. Given the dramatic changes that have occurred in land use and cover in the past decade in this region, the date of existing land cover data sets (e.g. 1992 EPA National Land Cover Database) render them of minimal use for regional planning. The SAP recommends that the WRP aggressively pursue and support the development of regional data sets required to run SWAMP. This will involve the collection of existing data, as well as the acquisition and management of new data. The major types of data and the status of efforts to collect and/or acquire them, are given below:

- *Digital elevation model (DEM*): This detailed, digital topographic map used to determine riparian zone boundaries and drive assessment of physical components of the model. In the spring 2002, NOAA agreed to acquire IfSAR data for the WRP, and manage this data to develop a DEM model for the entire study area.

- *Land use/land cover*: Land use/land cover data will be used to characterize surrounding land uses, riparian vegetation, identify riparian zone boundaries and serve as proxy data set for riparian vegetation. In spring 2002, NOAA agreed to acquire new data through the Coastal Change Analysis Project (C-CAP). Data are anticipated in September 2003.

- *Riparian zone boundaries*: Riparian zone boundaries define the area in which SWAMP assessment will be carried out. The boundaries are delineated using a combination of data sources including a DEM model and land use/land cover data. While proposals have been submitted to federal sources (NOAA, GAP analysis program) to fund this work, support to develop this important data set is not confirmed. The SAP recommends that the WRP pursue additional funding sources to undertake the development of this data layer.

- *Riparian vegetation:* Currently, there is no regional GIS data layer describing riparian vegetation in southern California coastal watersheds. While land use/land cover data being developed by the NOAA C-CAP project can be used for some of the efforts, the resolution of this data source is 30 m. Many riparian corridors have riparian zones of widths less than 5 m. Therefore, the SAP recommends that the WRP work to develop a up-to-date map of riparian zone vegetation with a resolution of 2-5 m. This data layer will not only be used to in the SWAMP assessment, but also be incorporated into an inventory of wetlands and riparian resources in coastal watersheds (see Section IV).

- *Collection of existing data*: There are a number of existing GIS data layers that must be collected as a part of the SWAMP assessment. The County Task Force watershed coordinators, whose positions are funded by a Proposition 13 grant to Environment Now, will be assisting in the collection of the necessary data layers for the watersheds in each county.

All GIS data layers developed to support the SWAMP assessment will be made available online to the public through the WRP Information Station. They will also be used to support the development of a regional program to monitor freshwater wetlands and riparian resources in coastal watersheds.

CHAPTER IV. REGIONAL MONITORING OF WETLANDS AND RIPIARIAN ECOSYSTEMS

A. Need for Monitoring

By setting regional goals and adapting the quantifiable recovery objectives specified in this document, the WRP will have a set of clearly defined goals for the program and the elements of wetland structure and function that must be restored for ecosystem recovery. The next logical step is to implement a monitoring program that assesses baseline conditions, measures progress towards recovery, and evaluates the effect of anthropogenic stressors constraining recovery.

This program would have many other benefits. Among them, it would provide an integrated and cost-effective regional approach to addressing the management questions of WRP partners. It would streamline reporting of monitoring data, making them more accessible for routine scientific evaluation of restoration and management techniques. A recent study by a National Academy of Sciences Panel of the compensatory mitigation program found that the "no net loss goal" is not being met because of the lack of compliance monitoring and the success criteria do not assure establishment of wetland functions, particular those important in the landscape context (National Academy of Sciences 2001). Although the WRP is a non-regulatory program that is not involved with assessing compensatory mitigation, the development of a standardized methodology to evaluate wetland ecosystem structure and function within a landscape context could facilitate assessment of wetland regulatory and management policy including compensatory mitigation.

B. Recommended Approach

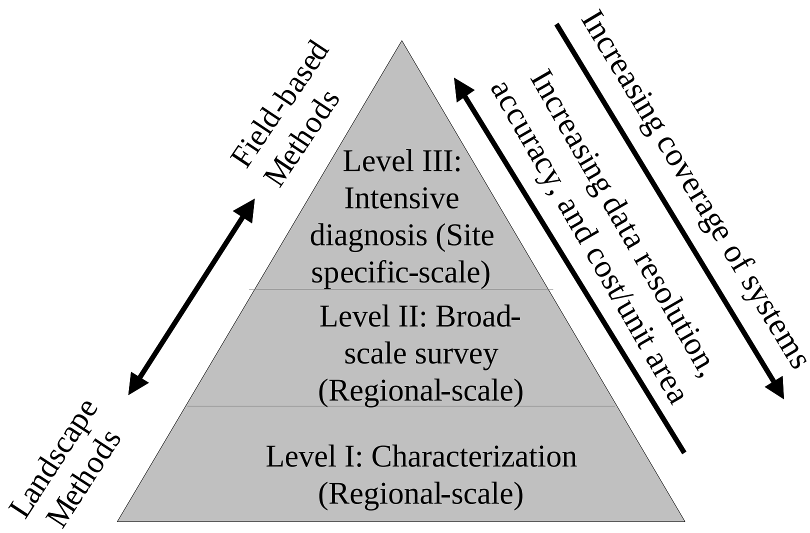
The SAP recommends that a regional wetlands monitoring program be established with three tiers of assessment. These three tiers address very different types of management questions (Fig. 8). Level I, the most basic kind of monitoring, is the characterization of the resource at the regional scale. The WRP Coastal Wetlands Inventory and the National Wetlands Inventory are both good examples of a Level I assessment. This type of monitoring addresses management questions about the extent of resource, without being able to address the condition of those resources. At this level, landscape or remote sensing methods are typically used to describe the resource. Use of landscape methods implies that assessment is conducted at a coarser resolution, but coverage of the wetland resources is region-wide.

Level II-type of monitoring goes beyond characterization to address management questions on resource condition and stressors on a regional scale. Using both remote-sensing and field based methods, assessments at this level also attempt to address management information needs on a regional scale. However, since the questions being addressed are more expensive to address, the assessments at this level are usually conducted by performing a survey on a random sample of wetland sites throughout the region. There are relatively few examples of this level of monitoring in southern California. Notable examples include the coordinated regional monitoring survey of the offshore environments of the Southern California Bight last conducted in 1998, the U.S. EPA Environmental Monitoring and Assessment Program (EMAP) study of subtidal habitats in

Southern California estuaries, and the California Dept. of Fish and Game annual survey of endangered coastal marsh birds.

Level III is the most intensive level of assessment, addressing detailed management questions of stressors and condition on a site-specific scale. It is perhaps the most commonly conducted form of monitoring in southern California wetlands. Relying mostly on field-based methods, the quality of information generated is much higher than in Levels I and II, but because of the expense, the information is collected at a few sites, and the information cannot be extrapolated to the region. Examples of Level III-type monitoring include data collected pre- and post-restoration, compensatory mitigation monitoring, assessments and species studies related to academic research, and monitoring performed as a part of management plans for federal and state lands.

Fig. 8. Components of a comprehensive regional wetlands monitoring program



The WRP and its partners are already conducting components of this idealized wetlands monitoring program. The Southern California Coastal Wetlands Inventory, prepared in 1996-1997 is a Level I assessment. WRP partners have also been conducting assessments at Level III, including monitoring associated with restoration projects, reserves, threatened and endangered species, and academic research. The level at which little work has been conducted is that of a regional survey (Level II).

An integrated regional monitoring program should address the specific information needs of the WRP agencies as well as the condition of the resource and the progress of recovery. It would also provide feedback on the success of restoration and management strategies, identify stressors common to wetland resources in the region, and provide information useful to set regional priorities for restoration and management. We recommend that this program be grounded in the elements of wetland ecosystem structure and function detailed in the quantifiable recovery objectives. A description of how quantifiable recovery objectives can be linked with a regional monitoring program is given in Section IV.C below. Specific SAP recommendations for the development and implementation of such a program follow in Section IV.D.

C. Linking Quantifiable Recovery Objectives with Monitoring

One of the principal motives in establishing quantifiable recovery objectives is to be able to draw direct links between recovery objectives and management actions. These links are established though monitoring to assess progress towards recovery objectives, using indicators that evaluate the success of management actions, the condition of the wetlands (natural and under restoration), and the stressors (e.g. contaminant runoff, population pressure) that may adversely impact the progress of recovery. It is in this manner that the quantifiable recovery objectives serve as the conceptual framework for a wetlands monitoring program

The development of the assessment framework and suite of indicators to assess progress towards the regional objectives and success of management actions must be specific for each of the major wetland classes (i.e. estuarine, marine, palustrine, lacustrine, riverine; Cowardin et al. 1979). However, to further clarify what we mean by indicators, and how they are used, we will illustrate several indicators that could be used to evaluate progress towards a recovery objective, using the estuarine wetland class as an example.

As noted earlier, there are five elements to assessing recovery of landscape elements of structure and function in estuarine wetlands. We will choose one of these, landscape hydrologic connectivity, to follow this thought process. There may be a number of restoration or management actions that could be taken to improve an estuarine wetland's landscape hydrologic connectivity. These would generally fall under the categories:

1. Restoring the connection to the ocean, either by reducing the number of wetlands with tide gates or water control structures;
2. Removing levees or dikes that hydrologically isolate wetlands from their freshwater sources (i.e. rivers) or upland buffers zones.

To evaluate the degree to which the management actions at a particular site have addressed this objective and recovery as a whole, assessment indicators can be selected. Indicators can vary – depending on the level of assessment (I-III) and the monitoring question (e.g. Table 3). They can vary in the expense and level of labor involved to monitor them. Thus, at a restoration project, long term monitoring of water levels may be required of the permitee to verify the restoration of hydrologic function, and relate this to the recovery of species and habitat diversity. On a regional level, we may choose to conduct a survey in which one site visit is made to evaluate the presence of tide gates or water control structures, or measure the percent attenuation of spring tides inside and outside the estuary. The indicators that are chosen are a function of the management questions that drive the monitoring, and the trade offs between cost of measuring them versus quality of information obtained.

Table 3. Demonstration of connection between recovery objective, management action, and indicator chosen to evaluate that action in estuarine wetlands.

<table>
<tr><th colspan="2" rowspan="2">Recovery Objective</th><th rowspan="2">Management Action</th><th colspan="2">Sample Indicator</th></tr>
<tr><th>Site-specific</th><th>Regional Survey</th></tr>
<tr><td rowspan="2">Recover landscape elements</td><td rowspan="2">Recover landscape hydrologic connections</td><td>Increase number of wetlands with full tidal flushing</td><td>Occurrence of water control structure</td><td>% of wetlands with muted versus full tidal flushing</td></tr>
<tr><td>Remove levees that hydrologically isolate wetlands from freshwater source or upland habitat</td><td>Monitor water exchange with river or frequency of flooding of upland habitat</td><td>Frequency distribution of wetlands by % of perimeter of wetland hydrological isolated by levees</td></tr>
</table>

D. SAP Recommendations for Wetlands Regional Monitoring Program

The SAP recommends that the WRP develop a comprehensive regional wetland monitoring program by implementing a level II-type of assessment, and by strengthening the coordination and developing synergy between all three tiers of monitoring. Specific recommendations are outlined below:

1. *Update present-day and historical inventories of southern California wetland ecosystems*: Currently, the present-day inventory covers only coastal wetlands and is not in a digital format. This inventory should be updated with new digital imagery and expanded to include freshwater wetlands and riparian areas in southern California coastal watersheds. Additional data layers should be added that describe, at minimum, the geologic and physiographic context in which these wetlands are located. This data set would be used as a baseline with which to document future changes in wetland resources. A historical inventory should also be created, using available data sources to document changes in wetland acreage by habitat type versus land use from time period of European settlement in the region. These data would also be utilized to document loss in acreage and diversity of habitat types from historic conditions, a source of important information in the establishment of regional habitat acreage goals (see Section III.A).

2. *Develop and implement a regional survey of wetland resource condition and stressors:* The WRP regional monitoring program should address the information needs of the WRP agencies, and assess the condition of the resource -- based on the elements of wetland ecosystem structure and function detailed in the quantifiable recovery objectives. Steps involved in developing this regional survey include assembling a project team representing WRP partner agencies, defining monitoring questions targeting specific management concerns, updating inventory to serve as a sample frame for site selection, and developing and verifying regional survey methodology. A proposal has been submitted to the EPA Section 104 program (Feb 2002) to update the wetland inventory and begin development of regional survey methodology.

3. *Develop a program to monitor the success of restoration projects:* The methodology developed for the regional survey of wetland resources can be adapted and used in the implementation of a functional assessment to evaluate the success of WRP restoration projects. Compatibility with the regional survey methodology assures that the data generated from these projects contribute to the regional assessment of wetland resource condition.

4. *Improve coordination of site-specific monitoring:* Monitoring conducted at the third tier, should utilize the standardized methodologies developed as part of the regional survey, and a common template for electronic reporting of data. Knowledge gained in restoration projects is often buried in monitoring reports or not completely disclosed by private sector consultants. Failed restoration strategies should be part of an iterative process that lead to better projects (Hackney 2000). Currently, data collected in restoration projects are not standardized in terms of the types of attributes monitored as well the format in which they are reported. The SAP recommends that a minimum set of monitoring requirements be adopted and that a standardized electronic format be required for reporting monitoring data. This data can then be made available to the scientists and the public to expand our understanding of the success and failures of specific restoration and management strategies.

5. *Develop administrative and financial infrastructure to support regional wetlands monitoring program*: The WRP should develop the administrative infrastructure and provide continuing support for implementation of regional monitoring program, including the analysis and dissemination of data.

CHAPTER V. SUMMARY OF SAP RECOMMENDATIONS

The SAP advocates the implementation of three initiatives to improve the regional planning of wetland ecosystem restoration and management. These are:

1. Establish quantifiable recovery objectives;
2. Develop decision support tools to aid in prioritizing preservation and restoration activities; and
3. Implement a regional monitoring program to measure the progress towards objectives.

The major attributes of wetland ecosystem structure and function important to recovery are identified in five quantifiable recovery objectives detailed in this document. The objectives and attributes identified should drive the assessment frameworks for a regional wetlands monitoring program, and for the decision support tools to prioritize the preservation and restoration activities of the WRP.

The SAP recommends that the WRP develop decision support tools to help prioritize the funding of preservation and restoration activities based on the ecological criteria outlined in the quantifiable recovery objectives. The SAP advocates that the WRP undertake two types of decision support projects: 1) establishment of habitat acreage goals, and 2) prioritization of riparian corridor preservation and restoration in coastal watersheds. Implementation of a habitat goals project depends on the development of data sources for this assessment. The SAP recommends that the WRP improve the historical and present-day inventories by habitat type, and catalog monitoring data that can be used to develop habitat requirements for wetland species.

The SAP also recommends that the WRP pursue the development of a decision support tool that will aid in identifying high priority riparian areas for preservation and restoration. This tool could be utilized by the WRP Managers group to guide the annual project selection, and by the WRP County Task Forces as a preliminary screening tool to develop priorities for the watershed management planning process. The WRP can support the implementation of the SWAMP decision support tool by: 1) reviewing SWAMP assessment framework currently under development, and 2) developing data layers to support the SWAMP assessment.

An integrated regional monitoring program can aid in assessing wetland resource extent and condition, guiding wetland restoration practices, managing watershed stressors, and verifying the effectiveness of wetland regulatory and management policy. Specific SAP recommendations for the implementation of this program include the need to 1) update present-day and historical wetland inventories, 2) develop a regional survey of resource condition and stressors, 3) develop a program to monitor success of WRP restoration projects, 4) improve coordination of project-specific monitoring, and 5) develop the administrative infrastructure to support a monitoring program.

GLOSSARY OF TERMS

Estuarine wetlands – Estuarine wetlands are subtidal and intertidal habitats that are semi-enclosed by land, have access to the open ocean, and in which ocean water is at least occasionally diluted by freshwater runoff from the land (Cowardin et al. 1979).

Habitat -- A collective term for the resources required by a species for its survival and reproduction -- the place where a species can be found. Habitat includes biological components such as the vegetation and fauna that serve as food sources and cover, and the geologic, hydrologic and geomorphic processes that serve as the foundation for the biotic interactions.

Habitat type – A term use to define the collective physical and biological resource (habitat) requirements shared by a group of species.

Hydric soil – Soil that is wet long enough to periodically produce anaerobic conditions, thereby influencing the growth of plants

Hydrophytes – Any plant growing in water or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content.

Lacustrine wetlands – Wetlands which have the following characteristics: 1) situated in a topographic depression or a dammed river channel, 2) lacking trees, shrubs, persistent emergents, emergent mosses, or lichens with greater than 30% areal coverage, and 3) total area exceeds 8 ha (20 acres; Cowardin et al. 1979)

Marine wetlands – Subtidal and intertidal wetlands found on the oceanic continental shelf and high-energy coastline. Habitats are exposed to the waves and currents of the open ocean and the water regimes are determined primarily by the ebb and flow tides (Cowardin et al. 1979).

Mesophyte, mesophytic – Any plant growing where moisture and aeration conditions lie between extreme (plants typically found in habitats with average moisture conditions, not usually dry or wet).

Riverine wetlands – Wetlands contained within a channel system with water containing salinity of less than 0.5 part per thousands. A channel is an open conduit either naturally or artificially created which periodically or continuously contains moving water (Cowardin et al. 1979).

Palustrine wetlands – All non-tidal wetlands dominated by trees, shrubs, lichens, persistent emergents, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5 ppt. The palustrine class also include non-vegetated wetlands, but with all of the following characteristics: 1) area less than 8 ha (20 acres), 2) active wave-formed or bedrock shoreline features lacking, 3) water depth in the deepest part of the basin less than 2 m, and 4) salinity less than 0.5 ppt (Cowardin et al. 1979).

Preservation -- *Preservation* includes the acquisition of fee title or conservation easements in wetlands, riparian areas, and associated upland habitats that are presently in private ownership and therefore not subject to conservation guarantees.

Restoration -- *Restoration* specifically refers to actions taken to obtain a former state of a natural condition. In the context of this paper, is the re-creation and enhancement of wetland habitat.

Riparian ecosystem – Using the US EPA definition, this refers to a **"**vegetated ecosystem along a waterbody through which energy, materials, and water pass. Riparian ecosystems characteristically have a high water table and are subject to periodic flooding and influence from the adjacent water body. These systems encompass wetlands, uplands, or some combination of these two landforms. They will not have in all cases the characteristics necessary for them to be also classified as wetlands" (EPA 2001).

Riparian area – For the purposes of this document, riparian areas or zones refer to the transitional areas upland of wetlands that either 1) support predominantly mesophytic vegetation (trees, scrub and herbaceous cover) or 2) have soil that is predominantly non-hydric. Riparian areas are not just unique to the upland transition zones of riverine wetlands (in linear corridors), but can also be found in adjacent to palustrine, lacustrine and estuarine wetlands.

Wetland – Using the U.S. Fish and Wildlife definition, wetlands are "lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For the purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year" (Cowardin et al. 1979).

Wetland Ecosystem -- For the purposes of this document, "wetland ecosystem" includes both wetlands and the transitional and adjacent upland habitats.

Wetland Recovery – As used in this document, the "recovery" refers to both the response by the wetland ecosystem to restoration and enhancement activities, as well as a demonstrated resilience of the wetland ecosystem to the natural and anthropogenic stressors

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APPENDIX B: DEFINING MONITORING OBJECTIVES AND ASSESSMENT QUESTIONS

The process of defining monitoring objectives requires input from both the resource's management and scientific communities. Agreed-upon objectives can be articulated in the form of questions that the monitoring program should be designed to ultimately answer. Bernstein *et al.* (1993) has defined a framework for establishing monitoring objectives, starting with the most fundamental tier, and building in complexity. In this framework, Level I[1] is defined as broadly stated public and management core concerns about the resource. The next level of detail of monitoring objectives to be fleshed out is Level II, which covers management and scientific objectives and includes specific statements about temporal and spatial scales, reference conditions, and the monitoring approach to be used. Level III addresses measurement goals that identify the types and amounts of change to be monitored, and Level IV deals with specific technical plans and methods for implementing monitoring.

Because the formulation of monitoring objectives begins at the most fundamental level, analogous Level-I questions tend to be asked by various state monitoring efforts, specifically:

- Where are the resources of interest, and how many units are there?
- What is their general condition?
- Is resource condition getting better or worse over time?
- What are the effects of management actions on the resources of concern?
- What are the causes of their current condition? What stressors are at play?

The Level-I monitoring objectives, or management questions, developed for the IWRAP through a series of meetings between members of the SAP and the Wetlands Recovery Project (WRP) Managers Group, are provided in Table B1. These questions are further divided into Levels 1, 2 and 3, reflecting the tier at which the questions are to be addressed in terms of spatial context (from the level of the region, to site-specific) and intensity of monitoring (from remote sensing, to intensive field work).

[1] It should be noted that Level I *sensu* Bernstein *et al.* (1993) is distinct from the Level-1 assessment tier pertaining to the "pyramid" of types of monitoring that forms the basis of the IWRAP.

Table B1. General management questions grouped by assessment tier.

Tier	Management Question
1	What are the locations and sizes of wetlands in southern California and how are they distributed throughout the region, by habitat type?
2	What is the condition of wetlands and associated resources on a regional scale and how is it changing over time?
	What are the major stressors on wetlands and how are their magnitudes changing over time?
	What are effects of restoration and mitigation projects on the regional condition of wetlands and associated resources?
3	Are wetland restoration and enhancement projects achieving their objectives?
	What are the stressors affecting the condition of wetlands at the project scale?
	What are the direct and indirect impacts of urban and agricultural development/infrastructure projects on wetlands and associated resources?
	What are the effects of management actions on the condition of wetlands and associated resources on the project scale?

The organization of monitoring objectives in the manner outlined by Bernstein *et al.* provides a useful framework within which to make logical steps that lead from defining the key management questions (Level I) to specifying the technical detail of monitoring designs (Level IV). It defers the focus on technical details until after the more fundamental goals and priorities of the monitoring program are well defined and agreed upon by all parties. In developing monitoring recommendations for estuarine monitoring, the SAP followed an analogous process that began with taking each management question (Table B1) and first articulating a number of *scientific questions* addressing each management question. The next step was to articulate a number of potential *assessment questions* addressing each of the scientific questions.

Scientific questions can be thought of as questions that bridge the gap between the general concerns expressed in the management questions, and the more specific technical detail needed to complete the actual monitoring plans addressed in the assessment questions. For example, if a management question is: "What is the condition of wetlands and associated resources on a regional scale and how is it changing over time?," a potential scientific question addressing this would be: "*What is the status of estuarine plant communities in the region, and how is it changing over time?*"

Ideally, the assessment questions associated with each scientific question would take the technical detail one step further, by defining the population to be monitored, selecting the most appropriate indicator(s) of condition, and, when applicable, selecting the most appropriate time frame for sampling. An example of an assessment question addressing the above scientific question is: "*What is the distribution of native and nonnative plant species diversity, abundance, and relative percent cover at five index locations within the marsh plain at the end of the growing season (~September)?*"

The result of the assessment-question development process is such that several assessment questions pertain to any given management question. The assessment questions are significant in that they will ultimately guide the selection and development of protocols, and the overall sampling design, for the

IWRAP. The process the SAP followed in generating them was a stepwise one. It guaranteed that the original management objectives were never lost in the process of developing the monitoring recommendations. Figure B1 provides a schematic overview of this process.

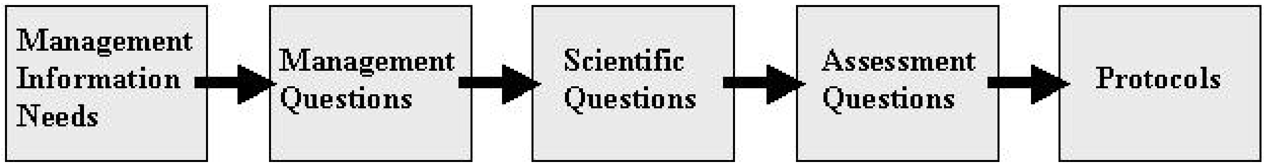


Figure B1. The steps in the process of developing assessment questions and protocols responsive to management information needs.

APPENDIX C: WETLANDS DEFINITION AND CLASSIFICATION

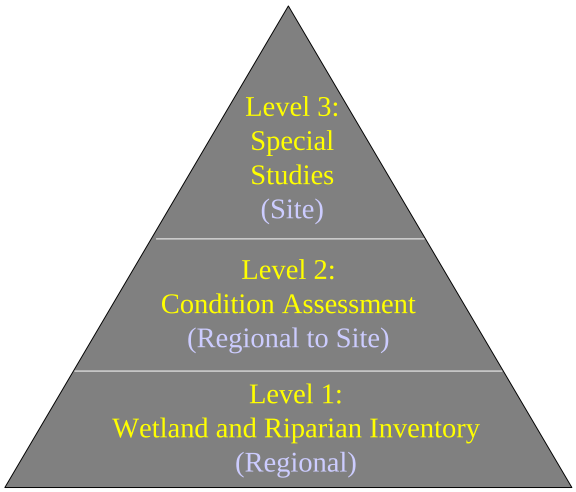
The wetland ecosystems of southern California include five classes, or systems, based on the typology established by Cowardin *et al.* (1979). Table C1 provides a description of each.

Table C1: Southern California wetland class and definitions

Class	**Definition** (Cowardin *et al.* 1979)
Marine	*Subtidal and intertidal wetlands found on the oceanic continental shelf and high-energy coastline. Habitats are exposed to the waves and currents of the open ocean; water regimes are determined primarily by the ebb and flow tides.*
Estuarine	*Estuarine wetlands are subtidal and intertidal habitats that are semi-enclosed by land, have access to the open ocean, and in which ocean water is at least occasionally diluted by freshwater runoff from the land.*
Riverine	*Wetlands contained within a channel system with water containing salinity of less than 0.5 part per thousands (ppt); a channel is an open conduit either naturally or artificially created which periodically or continuously contains moving water.*
Lacustrine	*Wetlands which have the following characteristics: 1) situated in a topographic depression or a dammed river channel, 2) lacking trees, shrubs, persistent emergents, emergent mosses, or lichens with greater than 30% areal coverage, and 3) total area exceeds 8 ha (20 acres).*
Palustrine	*All non-tidal wetlands dominated by trees, shrubs, lichens, persistent emergents, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5 ppt. The palustrine class also include non-vegetated wetlands, but with all of the following characteristics: 1) area less than 8 ha (20 acres), 2) active wave-formed or bedrock shoreline features lacking, 3) water depth in the deepest part of the basin less than 2 m, and 4) salinity less than 0.5 ppt.*

APPENDIX D: THE TIERED APPROACH TO REGIONAL WETLAND ASSESSMENT

The basic conceptual approach of the IWRAP involves an integration of three tiers (or levels) of assessment activities. This general approach is advocated by the USEPA, and was adopted by the SAP in their 2002 position paper (Sutula *et al.*) The three levels of assessment address different types of management questions as well as the spatial scales and levels of intensity of effort inherent in each (Figure D1).



Parenthetical text refers to the spatial scale at which the assessment occurs within each level.

Figure D1. Schematic of tiered approach to regional wetland assessment.

Level 1 consists of inventories of wetlands and associated resources. The WRP Coastal Wetlands Inventory and the United States Fish and Wildlife Service National Wetlands Inventory (NWI) are both good examples of Level-1 monitoring. These inventories are the most basic component of a comprehensive wetlands assessment program. Level-1 monitoring addresses management questions about the extent of the resource, without being able to address condition. At this level, landscape or remote sensing methods are typically used to describe the resource. Use of landscape methods implies that assessment is conducted at a relatively coarse resolution, but coverage of the wetland resources is region-wide. Data produced by inventories are essential for habitat conservation, land-use planning, and identifying the spatial distribution and abundance of wetland and riparian resources, as well as assessing landscape-level trends in habitat change.

Level-2 assessment goes beyond extent, to address resource condition and stressors on a regional scale. Using both remote-sensing and field-based methods, Level-2 assessments are broad in scale and relatively coarse in resolution. There are relatively few examples of this level of monitoring in southern California; these include the coordinated regional monitoring survey of the offshore environments of the Southern California Bight conducted in 1994, 1998, and 2003, and the 2002 USEPA Environmental Monitoring and Assessment Program (EMAP) study of subtidal habitats in Southern California estuaries.

Level 3 is the most intensive level of assessment, addressing detailed management questions about stressors and condition on a site-specific scale. It is perhaps the most commonly conducted form of monitoring in southern California wetlands. Relying mostly on field-based methods, the precision of information generated is much higher than in Levels 1 and 2, but because of the level of effort required, the information is collected at relatively few, targeted sites, and cannot be extrapolated to the region. Examples of Level 3-type monitoring include data collected pre- and post-restoration, compensatory mitigation monitoring, assessments and species studies related to academic research, monitoring performed as a part of management plans for federal and state lands, and the California Department of Fish and Game annual survey of endangered, coastal-marsh birds.

The three-tiered assessment approach represents a cost-effective and flexible strategy to obtain information about the status and trends of wetland and riparian resources at the appropriate spatial scales. Level 1 and 2 assessments serve to identify major trends and potential areas of concern. The more intensive investigations, at Level 3, help to clarify fundamental mechanisms underlying trends in condition.

While the three levels of assessment are geared toward different spatial scales, answer different types of questions, and can each provide information independently of one another, they can also serve to inform and complement each other. For instance, Level 1, the inventory of southern California wetlands, provides a sample frame from which to select the sites of ambient (Level-2) monitoring activities when using a probabilistic survey approach to sampling. Level-2 monitoring can provide insights into trends in aspects of wetland condition that inform the choice of Level-3 special studies to investigate the causes of changes in condition, develop improved indicators, or to validate rapid tools and methods used in Level-2 monitoring. The regional estimates of condition provided by Level 2 also serve as a context within which to understand the results of Level-3 studies.

APPENDIX E: SAMPLING DESIGN CONSIDERATIONS

A number of spatial and temporal considerations come into play in planning regional monitoring activities for ecological resources. With regard to how sampling of each indicator should be executed in space and time, the SAP considered a number of possibilities.

Spatial Aspects

From a spatial standpoint, sampling can be conducted by censusing all southern California estuaries in a given sampling cycle, or the estuaries can be subsampled in a random fashion, so as to cover a predetermined number of sampling locations that are probabilistically assigned.

A probabilistic sampling design provides a statistically unbiased, objective assessment of the overall condition of the resource of interest. This survey design is a valuable tool for gaining region-wide perspective of wetland condition, with known statistical confidence, for a limited investment of sampling effort. The benefit of conducting probabilistic surveys is that, if site selection is random and all sites are sampled with a known probability, then information from the sampled sites can be used to infer the condition of sites within the region that were not sampled. This allows the results from a random sample of sites to be scaled up to represent the entire population of sites within a region. The only alternative method for generating such information would be to sample exhaustively (census) each site within that region. For most indicators, exhaustive sampling would be much more expensive than randomly sampling a subset.

For probabilistic sampling, sites are selected with a known probability of being drawn from the sample frame, based either on estuarine acreage or some discrete geographic unit. The sampling unit of choice depends on the nature of the assessment question. If the output of the assessment is best explained in terms of the percent of estuarine area that falls above or below a certain threshold, for example, then the sampling unit should be estuarine "area". An example of an indicator that lends itself well to such an approach is the level of a given sediment contaminant. This is, in part, because the output from the measurement of this indicator is a continuous value for which a cumulative distribution function (CDF[1]) can be generated, using the combined data from the regional assessment. CDFs provide a useful means of summarizing data reflecting regional estimates of condition with respect to any of a number of types of indicators.

Toxic-effect threshold values have already been determined for a number of contaminants, and these values can be used to estimate what percentage of wetland acreage in the region contains dangerous levels of a given contaminant. It is also possible to provide a measure of confidence of this estimate. In addition, the probabilistic sampling method accommodates the fact that a given indicator, such as sediment contaminants, may be patchy throughout a single estuary, such that, without comprehensive sampling within that estuary, it is not possible to generate a meaningful picture of its sediment-contaminants status. In such cases, an estimate of the status of the region as a whole, using a minimal number of sampling sites, may be more useful than an attempt to comprehensively characterize a number of individual estuaries.

[1] **Cumulative Distribution Function (CDF)** is also known as the distribution function, the cumulative frequency function, or the cumulative probability function. The CDF, $F(x)$, describes the probability that the random variable X assumes a value less than or equal to some value x, $F(x)=\text{Prob}(X \# x)$.

Alternatively, some questions, like that addressing the condition of the estuarine inlet, make sense only with an output expressed in terms of a discrete unit, such as percent of estuaries. In general, indicators of characteristics that are invariable across any given estuary (such as inlet closure), if subsampled, lend themselves well to a probabilistic approach, with "estuary" as the unit of sampling, because a comprehensive statement can be made about the condition of each estuary through the use of only one sampling event per estuary. Some assessment questions are best answered in terms of other discrete units at the sub-estuary level. For example, the data output for an assessment question about the score for a certain CRAM attribute, such as Biotic Structure, could be reported in terms of percent of CRAM assessment areas within the study area. The sampling unit, in this case, would be the CRAM assessment area, several of which could potentially occupy a single estuary.

When conducting a probabilistic sampling, there is a tradeoff between the level of assessment effort (and cost) and the level of statistical confidence that can be applied to the results of the assessment. An exponential relationship exists between the two, which allows selection of an optimum sampling effort based on these tradeoffs. The sample sizes recommended by the SAP for the various indicators reflect this consideration. It was decided that, for probabilistic sampling, 30 samples are adequate to generate estimates that meaningfully characterize the study region. Furthermore, in order to overcome the inherent bias toward large estuaries that would ordinarily result from a probabilistic sample draw, and to justly represent small estuaries in the IWRAP assessments, it was decided that estuaries should be pre-stratified into two size classes: small (tentatively defined as comprised of less than 100 acres) and large (tentatively defined as comprised of 100 acres or more). For many indicators, it is recommended that a random probabilistic draw be conducted separately within each size class, for a total of 60 sampling sites. However, because of the limited number of estuaries in the study region, for all indicators for which the sampling unit is the estuary itself, assessment of a total of 30 randomly selected estuaries (15, each, from the small and large estuarine size classes) is recommended.

It should be noted that when indicators require sampling at various strata within the estuary, there are two possible approaches to addressing this need, while maintaining the recommended sampling intensity. One possibility is to conduct sample draws such that 30 (if that is the recommended sample size for the indicator in question) sample sites fall within each of the strata (i.e., for a total of 90, if three strata are recommended). A drawback of this approach is that it would result in decoupling strata from each other within the estuary. The alternative is to ignore strata when drawing samples and then use unbiased rules for establishing sampling locations within the each of the 2 strata that were not "hit" when each point was dropped down. While the latter option necessitates the development of rules, and also potentially requires additional GIS and/or field effort in order to locate the sampling locations within each of the strata, for each estuary, it is the preferred, and therefore recommended, option when stratification is required.

SAP recommends that a single sample draw be conducted (without prior stratification, except for size-class stratification into small and large estuaries) and that geometric "rules" then be used to determine the locations of the sampling points within each of the remaining strata, per point (note: the rules themselves are not stipulated in the position paper). This approach guarantees that only a single sample draw will need to be made per size class, and that any point falling in an estuary will automatically have corresponding points in the different strata falling within the same estuary. This approach also allows relationships between strata within estuaries to be explored.

Because there are relatively few wetlands in southern California meeting the IWRAP definition of estuarine and lagoon systems; each of these wetlands is unique in many regards, and for some indicators, it is essentially meaningless to estimate estuarine condition at the regional level using a probabilistic survey. Therefore, while it is recommended that many indicators be assessed through a subsample of sites selected probabilistically, others will be more effectively addressed using the census approach. Often, because of the perceived uniqueness of each estuary within a region with respect to a specific indicator, the need arises to monitor all estuaries at regular intervals for that indicator.

A consideration borne in mind when determining the spatial parameters of sampling for each estuarine indicator is the fact that, for the Level-2 component of the IWRAP, the primary concern is for the outcome to reflect the region's estuarine resources as a whole. Although the temptation exists to design Level-2 monitoring in such a way that it yields useful information about individual estuaries as well, care must always be taken not to do so in a manner that compromises the statistical validity of the model for representing the entire region, or that unnecessarily increases sampling effort, and reduces its cost-effectiveness, for a negligible gain of site-specific information. This is because, for many of the assessment questions, multiple samples would need to be collected within any given estuary in order to make a meaningful statement about that estuary, and this would need to be done repeatedly from estuary to estuary in order to make a statement about the region. This becomes a problem if there is a limited pool of resources available for the sampling effort. Collecting detailed information about specific estuaries is a separate undertaking that is addressed by Level-3 assessment efforts. **It should be noted that the sampling approaches discussed for Level-2 assessment are not designed with the intention of generating profiles of condition for individual estuaries, and the output resulting from Level-2 assessment should be interpreted with this in mind.**

Temporal Aspects

With regard to the temporal component of sampling, some indicators should be sampled every 5 years, and others can be adequately assessed once every 10 years. Likewise, for indicators that are sampled every 5 years, the sampling can be done once every 5 years, all in the same year**,** for all sites and indicators (*i.e*., "synoptically"), or it can be "rotated," such that a subset of sampling is done each year, and a different subset is sampled each subsequent year until all sampling has been completed at the end of each 5-year cycle. Under the latter scenario, subsets can be clustered either by site, meaning that all indicators are measured at a subset of sites in any given year, or by indicator, meaning that only a subset of indicators are measured in any given year, but this is done for all sites. Because the synoptic approach is scientifically the most sound, SAP recommends that, if sufficient funds are available, this approach be adopted for the IWRAP.

Not all estuarine indicators are best sampled through the same temporal and spatial approaches; however, commonalities among certain indicators, in terms of the logistics of their assessment, permit groupings of indicators that are best sampled together on a given site visit. Efficiency of sampling and other cost considerations influenced the decisions of the SAP in this regard, and are reflected the spatial and temporal sampling recommendations. In addition, these considerations influence the potential costs associated with the various sampling activities.

In summary, the general Level-2 monitoring design recommended by the SAP is as follows: Sampling should be carried out synoptically for all indicators that are to be sampled over 5-, or 10-, year intervals. However, if it is not possible to secure bulk funding every five to 10 years, sampling should instead be conducted for 1/5 of the indicators, each year. This approach, if necessary, would be preferable to sampling all indicators at 1/5 of the sites each year, because it is more important to have the various sites temporally in sync with one another than to have all the indicators in sync for a subset of sites each year.

APPENDIX F: SUMMARY OF MONITORING RECOMMENDATIONS BY INDICATOR

Appendix F. Summary of Monitoring Recommendations by Indicator.

Wetland Habitat Types

Assessment Question:
What is the decadal change in areal extent and spatial distribution of wetland habitat types in southern California coastal watersheds, on a decadal time frame, at a base imagery scale of 1:48,000 or smaller?

Frequency:
every 10 years

Site selection:
census

Assessment method:
mapping

Assessment Output:
•raw digital geospatial data (maps) illustrating locations, area (size and shape), and characteristics of wetland habitat
•net change in areal extent of wetland habitat types by landscape position and/or geographic unit (i.e., sub-basin, basin, watershed, bioregion, region), over time

Management Uses:
•provides an understanding of the location of wetland resources to help managers identify potential future acquisition/restoration areas
•provides the locations of potential reference sites for use in assessment of restoration activities
•provides a means to assess the success in achieving the goal of "No Net Loss" of wetland resources at the level of the region
•provides a sample frame for Level-2 monitoring of wetland resources for the IWRAP

Riparian Geomorphic Boundary

Assessment Question:
Where is the boundary of potential riverine riparian habitat in southern California coastal watersheds, based on floodplain topographic breaks identified from a 10-m digital elevation model or better?

Frequency:
one time only

Site selection:
census

Assessment method:
mapping

Assessment Output:
•raw digital geospatial data (maps) illustrating boundaries of potential riverine riparian habitat based on topographic breaks in floodplain
•one-time assessment of total potential riverine riparian habitat

Management Uses:
•provides an understanding of the location of riparian resources to help managers identify potential future acquisition/restoration areas
•provides the locations of potential reference sites for use in assessment of restoration activities
•provides a sample frame for Level-2 monitoring of riverine/riparian resources for the IWRAP

Riparian Habitat Types

Assessment Question:
What is the decadal change in areal extent and spatial distribution of riparian vegetation communities in southern California coastal watersheds, using a base imagery scale of 1:48,000 or smaller?

Frequency:
every 10 years

Site selection:
census

Assessment method:
mapping

Assessment Output:
•raw digital geospatial data (maps) illustrating locations, area (size and shape), and characteristics of riparian vegetation communities
•net change in areal extent of riparian vegetation communities by landscape position and/or geographic unit (i.e. sub-basin, basin, watershed, bioregion, region) over time

Management Uses:
•provides a means to assess success in achieving the goal of "No Net Loss"of riparian-associated wetland resources at the level of the region

Habitat Changes through Projects

Assessment Question:
What is the yearly change in areal extent, spatial distribution, and condition of wetlands and riparian habitat types areas in southern California coastal watersheds as a result of restoration, development impact, and mitigation projects?

Frequency:
annually

Site selection:
census

Assessment method:
tracking of changes in acreage and condition (based on CRAM) using *Project Tracker*

Assessment Output:
•maps illustrating locations & area of wetland and riparian habitat created or lost by development impacts, restoration and/or mitigation projects & resulting yearly net change in areal extent of these resources
•information about changes in acreage and condition of habitat types in the *Project Tracker*

Management Uses:
•provides a means of assessing the success of WRP restoration projects in terms of project-related regional changes in acreage and condition of wetland and riparian habitat over time
•provides a means of assessing the success of mitigation for development-related impacts, in terms of regional changes in acreage and condition of wetland and riparian habitat over time

Habitat Changes through Recovery Efforts

Assessment Question:
What is the yearly change in areal extent, spatial distribution, and condition of wetlands and riparian habitat areas in southern California coastal watersheds that are in protected status as a result of acquisition and conservation projects?

Frequency:
annually

Site selection:
census

Assessment method:
tracking of changes in acreage and condition (based on CRAM) using *Project Tracker*

Assessment Output:
•maps illustrating locations & area of wetland and riparian habitat that have been put in protected status by conservation actions & resulting yearly net change in areal extent of these resources
•information about changes in acreage and condition of habitat types in the *Project Tracker*

Management Uses:
•provides a means of assessing the success of acquisition and conservation projects in terms of regional changes in acreage and condition of wetland and riparian habitat over time

Inlet Condition

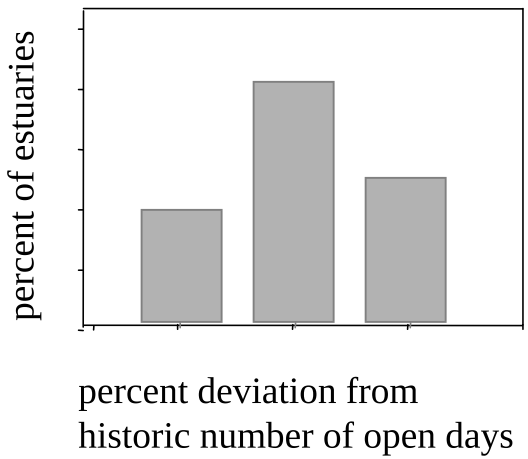
Assessment Question:
What percent of estuaries have modified inlet conditions relative to their historic condition, as indicated by the frequency of annual opening-and-closing cycles (normalized for climatic variation)?

Frequency:
every 5 years, compile annual data

Site selection:
probabilistic selection of 30 estuaries

Assessment method:
establishing historic inlet conditions, followed by periodic monitoring of inlet condition (where possible, through wetland managers/watershed groups)

Assessment Output:



Management Uses:
•provides an indication of the proportion of the year during with tidal exchange is achieved in the water bodies, and helps managers to make decisions about dredging / breaching berms

Tidal Range

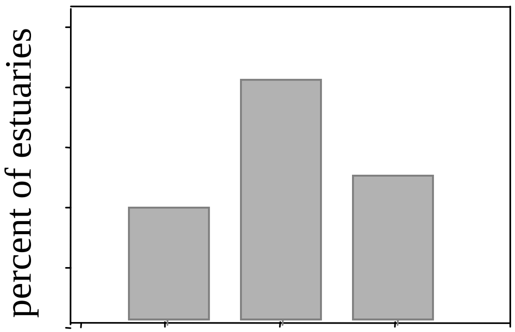
Assessment Question:
What is the effective tidal range in estuaries, and how is it changing over time?

Frequency:
every 5 years

Site selection:
probabilistic selection of 30 estuaries

Assessment method:
conducting mapping to determine basic shape and cross-sectional topography of the system and hydrologic control structures, followed by monitoring of water-surface elevation

Assessment Output:



1.) ratios of tidal amplitude at mouth *vs.* index points across the estuary
2.) ratio of durations of ebb *vs.* flow

Management Uses:
•provides an indication of the tidal range achieved in the estuaries, and helps managers to make decisions about dredging / breaching berms, and hydrologic controls, where applicable

Salinity

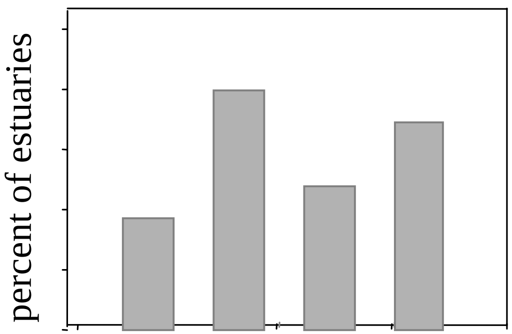
Assessment Question:
What is the distribution of salinity condition of estuaries, in terms of spatial and temporal fluctuations within and between them, over time?

Frequency:
every 5 years

Site selection:
probabilistic selection of 30 estuaries

Assessment method:
measuring salinity using sondes at the head of each estuary over two tidal cycles during the dry season

Assessment Output:



bins representing different salinity categories: freshwater, oligohaline, euryhaline, and hypersaline

Management Uses:
•provides an indication of the level of urban augmentation of freshwater into the estuarine system and/or inadequate tidal exchange

Water-column Chlorophyll *a*

Assessment Question:

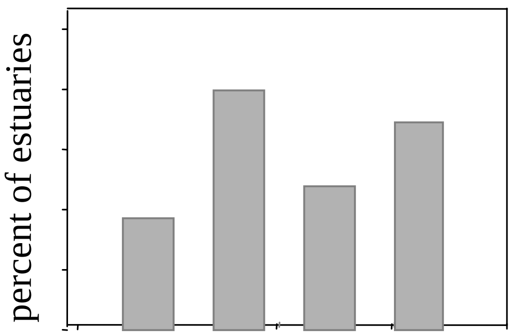
How is the distribution of water-column chlorophyll a in the region's estuaries changing over time?

Frequency:
every 5 years

Site selection:
probabilistic selection of 30 estuaries

Assessment method:
measuring water-column chlorophyll *a* using sondes with fluorometers at the head of each estuary over two tidal cycles during the dry season

Assessment Output:



bins representing different concentrations of chlorophyll *a*

Management Uses:

•provides an indication of the effectiveness of management actions addressing nutrient enrichment

Dissolved Oxygen

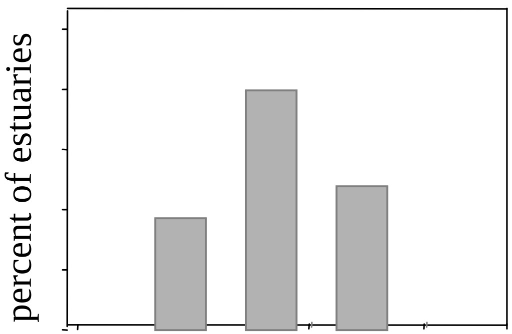
Assessment Question:
What is the extent and distribution of hypoxia or anoxia in estuaries, and how are the spatial and temporal patterns changing over time?

Frequency:
every 5 years

Site selection:
probabilistic selection of 30 estuaries

Assessment method:
measuring dissolved oxygen using data sondes at the bottom of the water column, at the head of each estuary, over two consecutive tidal cycles during the dry season

Assessment Output:



bins representing categories of varying levels of dissolved oxygen corresponding to conditions of anoxia, hypoxia, and saturating O_2

Management Uses:
•provides an indication of the effectiveness of management actions addressing eutrophication

Bathymetry and Elevation

Assessment Question:
How are estuarine bathymetry, intertidal elevations, and marsh habitat, as indicators of net sediment budget, changing over time?

Frequency:
every 10 years

Site selection:
census

Assessment method:
mapping with sonar along transects, and remote sensing to map elevational gradients and vegetation

Assessment Output:
•bathymetric/elevation/habitat maps of each estuary to facilitate an analysis of changes in depth of each estuary over time, and to provide an assessment of the overall sediment budget across the estuary, both in the marsh plain, and in subtidal areas.

Management Uses:
•provides information about changes in the net sediment budget for estuaries that enables managers to identify, for example, excessive inputs of sediment into the system and, if possible, rectify them at the source, or implement measures to prevent entry of sediment into the estuary
•provides bathymetric data can be used to determine the need for dredging

Sediment Constituents

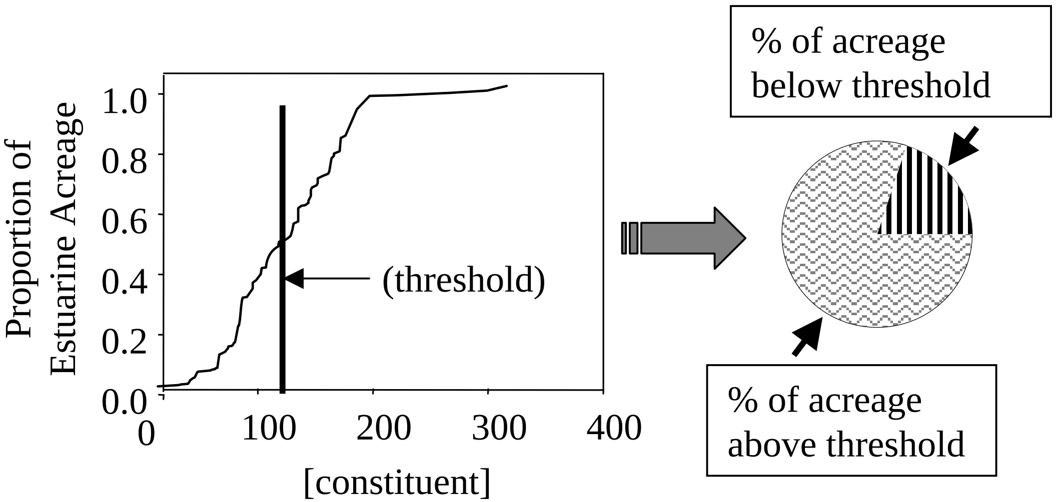
Assessment Question:
How are the distributions of constituents of subtidal marsh sediments changing over time?

Frequency: every 5 years

Site selection:
Level 2:
probabilistic selection of 30 sample sites in large estuaries and 30 in small
Level 3:
30 sample sites within the estuary, when possible, or fixed target sites

Assessment method:
collecting sediment samples and analyzing for their constituents in the laboratory

Assessment Output:
cumulative distribution functions (CDFs; see Appendix E) showing distributions of constituents' concentrations, and pie charts showing relative percentages of estuarine acreage above and below given thresholds



Management Uses:
•provides an assessment of sediment constituents that enables managers to identify whether there are, or have recently been, inputs of substances (such as heavy metals or pesticides) into the system at levels that could be harmful to humans or wildlife; identification of problem constituents can suggest sources, and by extension, possible means of abatement

Macroalgal Extent and Biomass

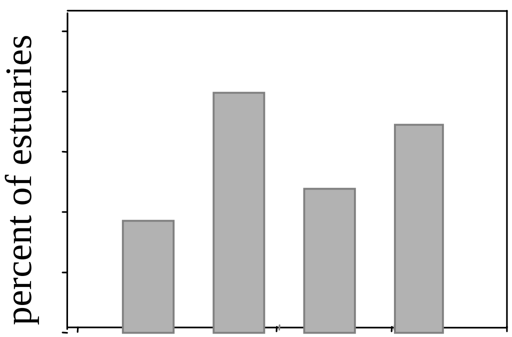
Assessment Question:
How are the distributions of macroalgal extent and biomass in intertidal areas changing over time?

Frequency:
every 5 years

Site selection:
probabilistic selection of 30 sample sites in large estuaries and 30 in small

Assessment method:
collecting macroalgal percent cover data across transects; collecting algal mat cores for dry-mass determination, by species

Assessment Output:



bins representing different percent coverage estimates for macroalgae; bins representing different biomass estimates for macroalgae

Management Uses:
•provides an indication of the effectiveness of management actions addressing nutrient enrichment

Plant Species Diversity and Abundance

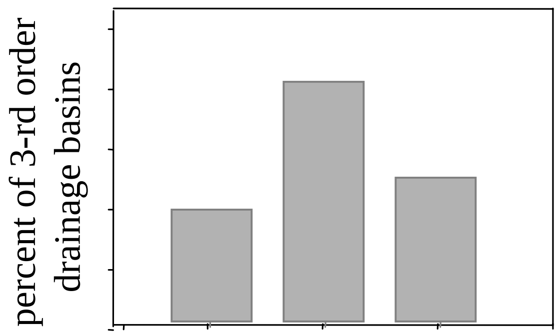
Assessment Question:
What is the distribution of native and nonnative plant species diversity, abundance, and relative percent cover at five index locations within the marsh plain at the end of the growing season (~September)?

Frequency:
every 5 years

Site selection:
Level 2:
probabilistic selection of 30 3rd-order drainage basins in large estuaries and 30 in small
Level 3:
all 3rd-order drainage basins within the estuary

Assessment method:
collecting plant species and percent cover data across transects

Assessment Output:



bins representing:
1.) relative percent cover of non-native and invasive species
2.) Shannon Index values

Management Uses:
•provides information on the composition of the marsh vegetation community and insight into exotic plant invasions that should be controlled
•provides an indication of the suitability of the estuary for supporting characteristic wildlife (*e.g.* extent and distribution of cordgrass for clapper rails)
•provides insight about drastic shifts in the vegetation community over time, which can be indicative of changes in other processes such hydrology, salinity, and sedimentation, that may need to be addressed by management actions

California Rapid Assessment Method (CRAM) Score

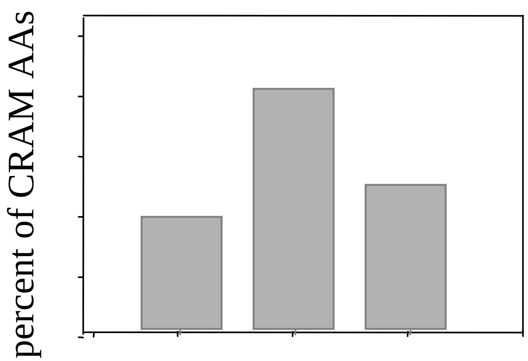
Assessment Question:
What is the distribution of CRAM Attribute scores in estuaries?

Frequency:
every 5 years

Site selection:
For Level 2:
probabilistic selection of 30 CRAM assessment areas in large estuaries and 30 in small
For Level 3:
all CRAM assessment areas within the estuary

Assessment method:
conducting CRAM field assessments at sampling locations

Assessment Output:



binned, numeric CRAM Attribute scores

Management Uses:
•a CRAM score provides a standardized, overall assessment of the condition of the wetland from the standpoints of 1) surrounding landscape and buffer, 2) hydrology, 3) physical structure, and 4) biotic structure; "subpar" CRAM scores can indicate degradation in the condition of a wetland due to anthropogenic stress, and can provide information about the potential sources of stress, and therefore, how they might be addressed

Benthic Infauna

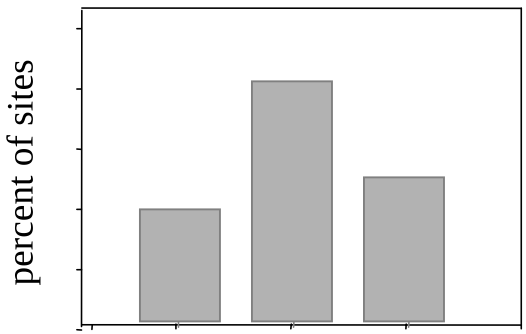
Assessment Question:
What is the community composition of infaunal organisms for subtidal areas of southern California estuaries?

Frequency:
every 5 years

Site selection:
Level 2:
probabilistic selection of 30 sample sites in large estuaries and 30 in small
Level 3:
30 sample sites within the estuary, or fixed target sites

Assessment method:
collecting infaunal invertebrates from subtidal portions of estuaries

Assessment Output:



bins representing:
1.) Shannon Index values
2.) (eventually) Benthic Response Index

Management Uses:
•provides information about the infaunal community that can be an indication of the complexity of the estuarine food web and ability to support a diverse array of wildlife
•provides a possible indication of anthropogenic stressors to the wetland in terms of the presence/absence of specific infaunal taxa

Fish Species Diversity and Abundance

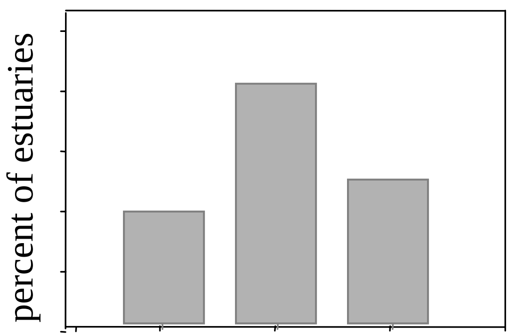
Assessment Question:
What is the distribution of species diversity and abundance values of native and of non-native fishes in two strata of southern California coastal lagoons and estuaries, and how is it changing over time?

Frequency:
every 5 years

Site selection:
probabilistic selection of 30 estuaries

Assessment method:
“exhaustively” catching fish in tidal channels and recording species, sex, and size

Assessment Output:



1.) Shannon Index values
2.) ratio of non-native to native Individuals
3.) flatfish presence/absence

Management Uses:
•provides information about the fish community that can be an indication of the complexity of the estuarine food web and ability to support a diverse array of wildlife
•provides a possible indication of anthropogenic stressors to the wetland in terms of the presence/absence of specific fish taxa

Eelgrass Depth Distribution

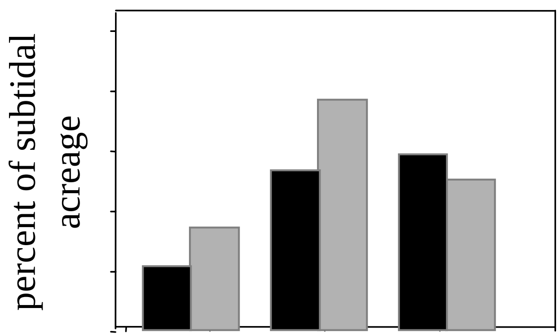
Assessment Question:
*What is the depth distribution of eelgrass (*Zostera *spp.), and how is it changing over time?*

Frequency:
every 5 years

Site selection:
probabilistic selection of 30 estuaries in large estuaries and 30 in small

Assessment method:
recording maximum and minimum depth of eelgrass beds along a transect array

Assessment Output:



bins representing minimum and maximum depths of eelgrass beds

Management Uses:
•provides an integrative indicator of overall health of the subtidal ecosystem, as well as a measure of habitat quality for estuarine fish species associated with eelgrass beds

Overwintering Bird Community Composition

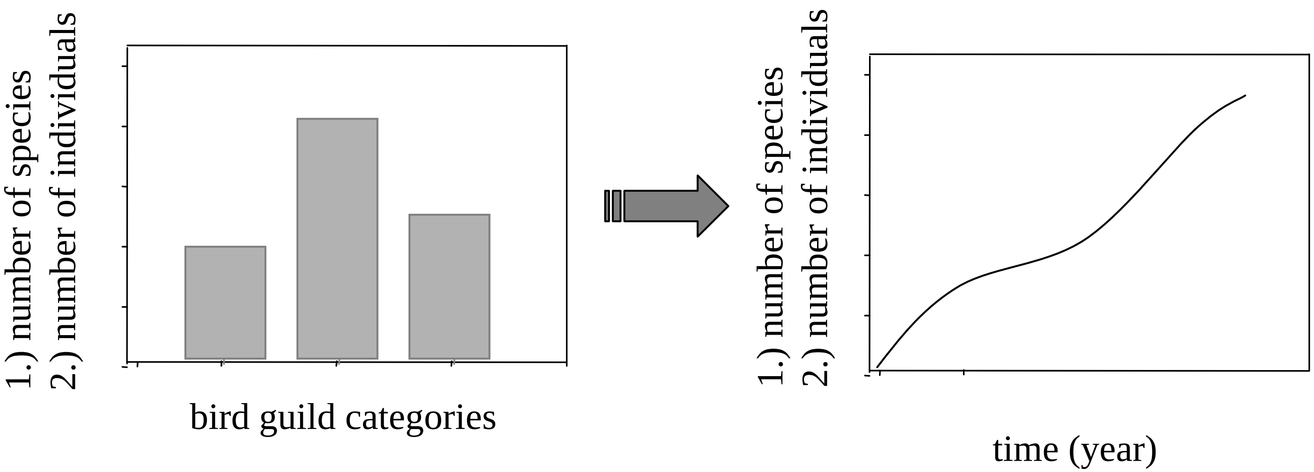
Assessment Question:
What is the distribution of species richness and abundance values (community composition) of overwintering birds within the different ecological guilds of southern California's intertidal wetlands, and how is this changing over time?

Frequency:
every 5 years

Site selection:
census

Assessment method:
conducting bird counts at all estuaries in the study area that support overwintering bird populations

Assessment Output: the following bar graphs are generated using the entire dataset from the study area as a whole; trends in overwintering bird use of the study can be tracked over time



Management Uses:
- •provides information about the bird community that can be an indication of the complexity of the estuarine food web and ability to support a diverse array of wildlife
- •provides a possible indication of anthropogenic stressors to the wetland in terms of the presence/absence of specific bird taxa

Light-Footed Clapper Rail

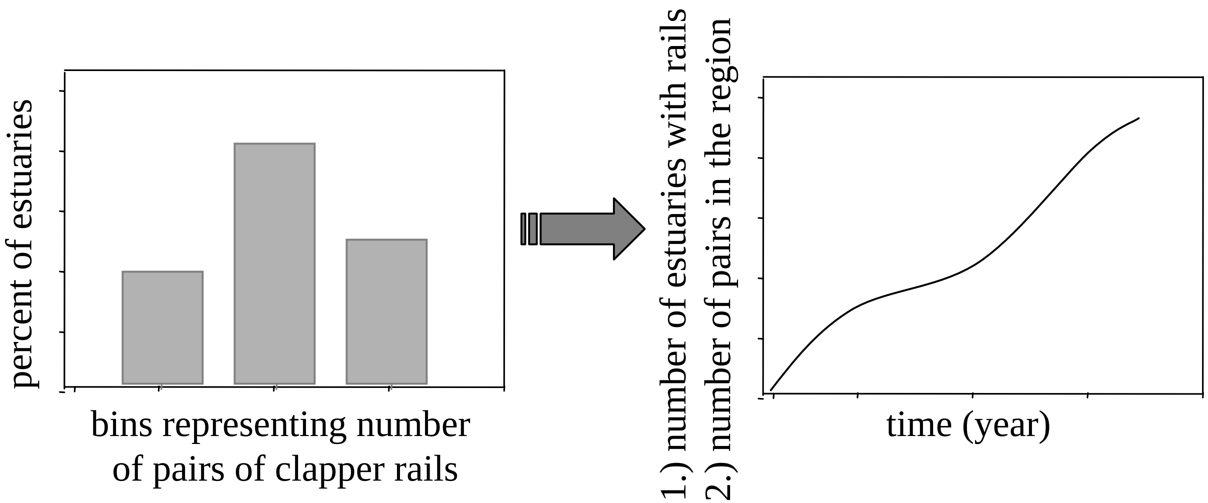
Assessment Question:
What are the distributions in the number of duetting pairs of light-footed clapper rail in southern California estuaries, and how is this changing over time?

Frequency:
every 5 years

Site selection:
probabilistic selection of 30 estuaries

Assessment method:
conducting spring call counts

Assessment Output:



Management Uses:
•provides information about the clapper rails that can be an indication of whether management actions geared toward recovery of the this listed species are
succeeding, or should be retooled
•provides an indicator of the condition of the marsh vegetation community in terms of the presence/absence and abundance of rails

Belding’s Savannah Sparrow

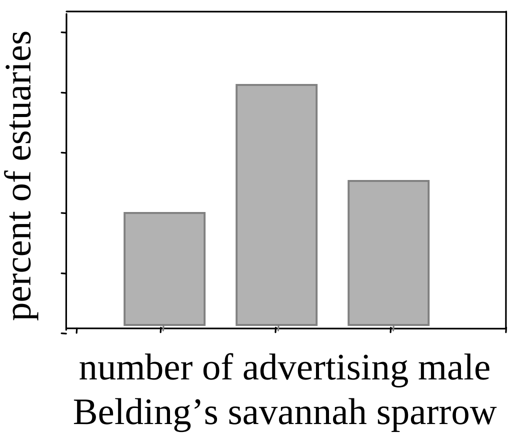
Assessment Question:
What are the distributions in the number of advertising males of Belding's savannah sparrow in southern California estuaries, and how is this changing over time?

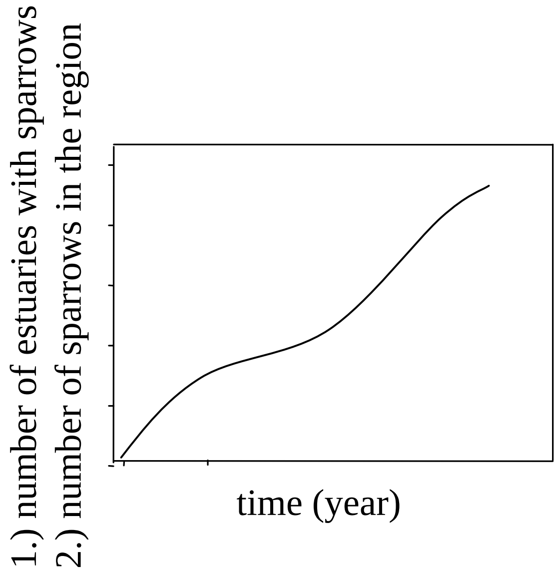
Frequency:
every 5 years

Site selection:
probabilistic selection of 30 estuaries

Assessment method:
walking transects through the *Salicornia* sp. and mapping bird localities and activity

Assessment Output:





Management Uses:
•provides information about the savannah sparrow that can be an indication of whether management actions geared toward recovery of the this listed species are succeeding, or should be retooled
•provides an indicator of the condition of the marsh vegetation community in terms of the presence/absence and abundance of savannah sparrows

Landscape Development Intensity Index

Assessment Question:

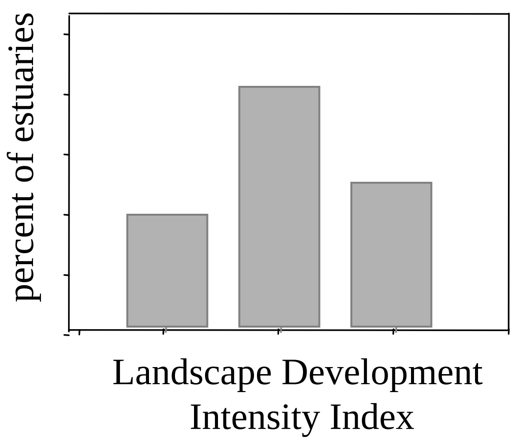
What is the change over time in the distribution of landscape development intensity indices for the upstream and unique catchment of the estuaries in the study area and how is this changing over time?

Frequency:
every 10 years

Site selection:
census

Assessment method:
conducting GIS analysis

Assessment Output:



Management Uses:

•provides knowledge of surrounding and upstream land uses, and how they are changing over time, which is indicative of potential sources of stress to the wetland, and possible future threats that can potentially be planned for in advance of adverse effects

Impervious Surface Area

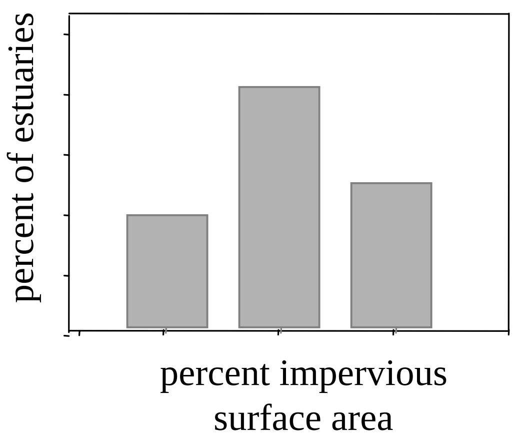
Assessment Question:
What is the change over time in percent impervious surface area for the unique catchment of the estuaries in the study area?

Frequency:
every 10 years

Site selection:
census

Assessment method:
conducting GIS analysis

Assessment Output:



Management Uses:
•provides knowledge of impervious surface cover of surrounding and upstream land uses, and how it is changing over time, which can be indicative of potential sources of hydrologic and contaminant-related stress to the wetland, and possible future threats that can potentially be planned for in advance of adverse effects

Population Density within the Contributing Watershed

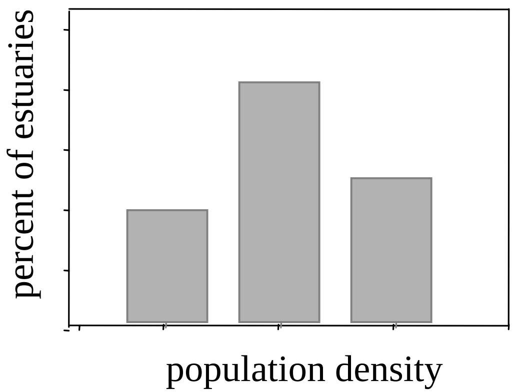
Assessment Question:
What is the change over time in the distribution of population of the contributing watershed for each of the estuaries in the study area?

Frequency:
every 10 years

Site selection:
census

Assessment method:
conducting GIS analysis

Assessment Output:



Management Uses:
•provides knowledge of population of the contributing watershed, and how it is changing over time, which can be indicative of potential stressors to the wetland, and possible future threats that can potentially be planned for in advance of adverse effects

CRAM Stressors

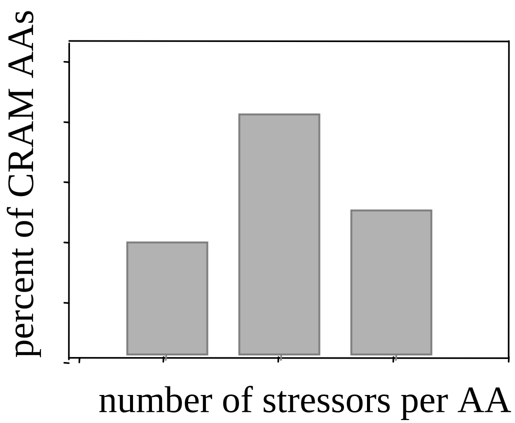
Assessment Question:
What is the distribution of the number of stressors from the CRAM Stressor Checklist identified in estuaries in the study area?

Frequency:
every 5 years

Site selection:
For Level 2:
probabilistic selection of 30 CRAM assessment areas in large estuaries and 30 in small
For Level 3:
all CRAM assessment areas within the estuary

Assessment method:
completing the CRAM stressor checklist at sampling locations

Assessment Output:



Management Uses:
•the CRAM stressor checklist provides a standardized, overall assessment of the likely presence of stressors to the wetland from the standpoints of 1) surrounding landscape and buffer, 2) hydrology, 3) physical structure, and 4) biotic structure; information about stressors, in conjunction with “subpar” CRAM scores, can provide insight into how the stressors might be addressed through management actions

APPENDIX G: DETAILED RECOMMENDATION FOR LEVEL-1 ASSESSMENT

Introduction

The purpose of this appendix is to provide details concerning the SAP recommendations regarding Level-1 assessment. Because implementation at Level 1 is the same for all wetland classes, the information in this appendix applies to all classes. General background and context for the management information needs and questions are provided, in addition to a summary of existing related efforts, and recommended indicators and sampling design.

Goals and Objectives for Level-1 Assessment

The goal of Level-1 assessment is to provide an inventory of wetland acreage and distribution, which can be used to track net changes over time. In addition, the resulting wetland and riparian maps provide the basis for selecting sites for Level-2 assessment.

Previous and Existing Level-1 Assessment Efforts

Currently, an effort is underway by the Resources Agency and the NWI to develop a statewide inventory of wetlands and riparian areas. The NWI program uses the Cowardin *et al.* (1979) classification system, one that is accepted as the national standard for wetland habitat mapping. This classification scheme is being utilized in all mapping done for the statewide inventory.

Over the past two years, the SAP has worked with the Resources Agency, NWI and other statewide partners to strengthen the consistency of mapping efforts and fine-tune the classification systems used to more adequately describe the diversity of California's wetlands. Specific activities have included:

- Developing a system of hydrogeomorphic (HGM) modifiers that describe the landscape position, geomorphic context, and hydrology of the wetland. These modifiers are coded along with the Cowardin classification used by NWI. The HGM modifiers are now being added to all new maps produced by NWI for the Resources Agency and the WRP.
- Developing local capacity for mapping by training local university geography departments
- Working with the Riparian Habitat Joint Venture and other partners to develop a set of minimum standards to map riparian habitat, including riparian vegetation communities and the riparian geomorphic boundary.
- Developing a GIS model to predict the geomorphic boundary of the riverine riparian zone. Output from the model represents potential riparian habitat. The boundary should be adjusted during photo interpretation of riparian vegetation to represent the actual riparian zone boundary (Sutula *et al.* 2006).

In 2006, the SAP will be demonstrating mapping products that use the methods specified for wetlands, riparian geomorphic boundary, and riparian vegetation community mapping. The resulting maps of the wetland habitat, riparian zone boundaries and riparian vegetation communities for five southern California watersheds will be reviewed by WRP partner agencies and used as a template for expanding inventory efforts in southern California coastal watersheds.

A clear priority for the implementation of the IWRAP is the update of the wetland and riparian resource inventory. SAP staff has partnered with the State Resources Agency and the NWI program to update maps of all wetlands in the WRP project area. The Resources Agency has made great strides towards completion of a statewide inventory of wetlands; however, of a total of 184 quads in the WRP project area, there are currently 25 quads for which we have no digital wetland data and an additional 23 for which the wetland maps date back to the 1980s. Given the rapid pace of urbanization of southern California, it is critical that these maps be updated with current data. In addition, riparian resources have not been mapped in a majority of the WRP jurisdiction. The SAP is working with the Managers Group, the Resources Agency, and United States Fish and Wildlife Service to identify sources for the funding required to complete the update of the wetlands and riparian resources inventory for the region.

SAP Recommendations for Level-1 Monitoring

The general approach to addressing the priority management issues for the WRP is identified in Table G1. The primary assessment activity to be undertaken for Level 1 is region-wide mapping of wetlands and riparian habitat, to be updated every 10 years. In this section, the recommended assessment activities are discussed with respect to recommended indicators and sampling design.

Table G1. Summary of management issues and rationale for Level-1 assessment activities.

Management Issue	Management Question	Design Approach
Where are the areas of wetland and riparian habitat that may need to be protected, restored or managed? *What type of wetlands and riparian habitat should we focus on for future acquisition and restoration?*	What is the change in the areal extent and spatial distribution of regional wetlands and riparian areas, by habitat types?	Region-wide Mapping of Wetland and Riparian Resources

The approach to addressing these management questions is to undertake region-wide mapping of wetland and riparian habitat types. The SAP recommends that three types of mapping activities be undertaken:

- Wetland habitat mapping
- Delineation of the riverine riparian geomorphic boundary (polygon within which riparian habitat can occur)
- Riparian vegetation communities

Table G2 gives the minimum criteria for the three mapping activities. Table G3 gives the specific assessment questions and anticipated output of these mapping activities. The SAP recommends that any wetland or riparian mapping undertaken by WRP partners outside of these decadal updates be conducted in a manner consistent (i.e., same classification system and minimum standards) with the system that NWI is currently using. In addition, it is recommended that a data-management system be employed to register and track changes in areal extent of wetland habitat types, by landscape position and/or geographic unit (*i.e*., sub-basin, basin, watershed, bioregion, region), over time.

Table G2. Summary of minimum criteria for mapping activities.

Mapping Activity	Base Imagery Characteristics	Classification System	Frequency	Algorithm Quality/ Accuracy[1]
Wetland Mapping	Digital color infrared aerial photography, minimum 1: 24,000 scale or better	Wetland habitat (Cowardin *et al.* 1979) HGM Modifiers (Sutula *et al.* 2002)	Every ten years at the level of the region, and every 5 years for areas undergoing rapid change	80% accuracy verified by groundtruthing, minimum standards for training and groundtruthing required
Riparian Vegetation Communities	Digital color infrared aerial photography, minimum 1: 24,000 scale or better	Holland community (Holland 1992)	Every ten years at the level of the region, and every 5 years for areas undergoing rapid change	80% accuracy verified by groundtruthing, minimum standards for training and groundtruthing required
Potential Riparian Zone Boundary	3-m digital elevation model, soils, geology, and FEMA maps	Riparian Habitat Joint Venture mapping standards (Sutula *et. al*. 2006)	One Time	See Sutula *et al.* (2006)

[1]The definition of "accuracy" in terms of wetland mapping depends on the wetland class and size under consideration. For small (e.g., some depressional) wetlands, accuracy may refer to whether or not the wetland is indeed present in that location, whereas for larger wetlands (such as estuarine and riverine wetlands), accuracy in mapping refers to the correct delineation of boundaries of the wetland.

Table G3. Level-1 assessment questions and anticipated output.

Assessment Question	Assessment Output
What is the change in areal extent and spatial distribution of wetland habitat types in southern California coastal watersheds on a decadal time frame at a base imagery scale of 1:48,000 or smaller?	Raw digital geospatial data (maps) illustrating locations, area (size and shape), and characteristics of wetland habitat. Net change in areal extent of wetland habitat types by landscape position and/or geographic unit (*i.e.*, sub-basin, basin, watershed, bioregion, region), over time
Where is the boundary of potential riverine riparian habitat in southern California coastal watersheds based on floodplain topographic breaks identified from a 10-m, or better, digital elevation model?	Raw digital geospatial data (maps) illustrating boundaries of potential riverine riparian habitat based on topographic breaks in floodplain ***One-time assessment*** of total potential riverine riparian habitat
What is the decadal change in areal extent and spatial distribution of riparian vegetation communities in southern California coastal watersheds using a base imagery scale of 1:48,000 or smaller?	Raw digital geospatial data (maps) illustrating locations, area (size and shape), and characteristics of riparian vegetation communities Net change in areal extent of riparian vegetation communities by landscape position and/or geographic unit (*i.e.*, sub-basin, basin, watershed, bioregion, region) over time

The habitat mapping to be undertaken in Level-1 IWRAP monitoring will include a mapping of submerged aquatic vegetation (SAV; *e.g.*, eelgrass, or *Zostera* spp., beds) on a decadal basis. This will include shallow subtidal and deepwater zones that are part of the geospatial range for IWRAP monitoring. Mapping of this underwater habitat will be accomplished through a combination of aerial imagery, acoustic techniques (*e.g.*, side scan sonar or single beam sonar), and diving. This mapping of submerged aquatic vegetation is not part of the standard NWI protocol and will need to be accomplished through a separate effort by IWRAP data collectors.

APPENDIX H: DETAILED RECOMMENDATIONS FOR LEVEL-2 ASSESSMENT

Introduction

The purpose of this appendix is to provide a detailed account of the SAP recommendations regarding Level-2 estuarine assessment. Unlike for Level 1, the approaches to Level-2 assessment will differ for the various wetland classes; as such, only a single wetland class, estuarine, is discussed in the present position paper. This appendix provides a summary of existing related efforts, general background and context for estuarine assessment questions, and recommended indicators and sampling design for the IWRAP.

Goals and Objectives for Level-2 Assessment

The goal of Level-2 assessment, in general, is to conduct an unbiased evaluation of the condition of the ecological resources of the region as a whole. This is a crucial element for gaining perspective that will allow resource managers to understand how the areas they oversee compare to the region at large. It is also an important tool for determining whether recovery efforts throughout the region (such as those undertaken by the WRP) are succeeding overall, and not just on a project-by-project basis, over time.

Previous and Existing Level-2 Estuarine Assessment Efforts

Existing regional monitoring efforts that occur, or have occurred, within the WRP study area have addressed several aspects of estuarine condition. Different programs are implemented at annual, or multi-annual intervals. Some assess water and/or sediment quality, while others focus on physical or biotic aspects of estuarine resources, or a combination of several of these.

EMAP

The USEPA Environmental Monitoring and Assessment Program (EMAP) 2002 Western Pilot was a study of subtidal and intertidal habitats in Western United States estuaries that examined factors such as sediment contaminants, macroinvertebrates, and vegetation. In addition to assessing these resources, the pilot sought to test the effectiveness of other, novel indicators and sampling designs to address concerns that are of direct importance to the region's wetland managers in targeted areas such as southern California and the San Francisco Bay Area. Some of the indicators and sampling approaches tested in the EMAP Pilot informed the recommendations of the SAP in developing the estuarine IWRAP. In particular, the probabilistic sampling method, piloted in the EMAP study, is recommended as a means of sampling a number of the estuarine indicators to be monitored.

SWAMP

The State Water Resources Control Board's Surface Water Ambient Monitoring Program (SWAMP) is an aquatic resources monitoring effort undertaken throughout the state. Each Regional Water Quality Control Board is responsible for implementing the program within its region. Different regions are currently at different stages of implementing their programs, and the approaches used vary somewhat among them. For example, the Central Coast (Regional Water Quality Control Board, Region 3) has been conducting the Central Coast Ambient Monitoring Program (CCAMP) for the past 7 years, which is the longest-running SWAMP-related ambient monitoring that has been implemented within a portion of the WRP study region.

While most of the CCAMP monitoring is conducted in freshwater systems, there is an estuarine component ("coastal confluences"), whose goal is to monitor water quality in nearshore areas, estuaries, and lagoons, to provide scientific information to Regional Water Quality Control Board staff, and the public, to protect, restore, and enhance the quality of the waters of central California (including Santa Barbara County). Bacteria, nutrients, and chlorophyll *a* are measured, and contaminant analyses are conducted on tissue, water, and sediment samples at target sites. This program provides a model for indicators and sampling designs to include in the IWRAP, and also provides a highly effective model framework for data management, and data sharing via the internet.

In southern California, most SWAMP activities have focused on assessment of water quality and benthic habitat in wadeable streams. Little effort has been directed toward assessment of ambient wetland condition, and almost no effort has been directed toward estuaries. Nevertheless, the overall goal of the SWAMP program is to evaluate the ability of all waters of the State to meet designated beneficial uses. Therefore, there is great opportunity for the IWRAP to support and assist the SWAMP program in meeting its overall goals.

Sensitive Species

Other large-scale estuarine monitoring that occurs in the WRP region includes the numerous surveys of Federal- and State-listed animal and plant species associated with recovery programs of the United States Fish and Wildlife Service and California Department of Fish and Game. The species monitored in estuaries include: the light-footed clapper rail, Belding's savannah sparrow, California least tern, western snowy plover, brown pelican, tidewater goby, and saltmarsh bird's beak. The SAP has recommended that some of these species be used as indicator species for estuarine condition. As such, the estuarine IWRAP is designed so as to incorporate information from the existing monitoring of certain species, such as the clapper rail and the sparrow.

SAP Recommendations for Level-2 Estuarine Monitoring

The following section discusses: 1) the evolution of final assessment questions from the initial Level-2 management questions identified in conjunction with the Managers Group, 2) assessment questions and the indicators of estuarine condition that are recommended to be monitored to address each one, and 3) appropriate sampling design for each indicator. In addition, the anticipated data outputs and management actions for each activity are discussed.

Evolution of Assessment Questions for Level-2 Monitoring of Estuaries

As was introduced in Chapter I, the SAP used as a starting point the Management Concerns and their relationship to the WRP Quantifiable Recovery Objectives (Sutula *et al.* 2002) in order to generate "scientific" questions, and their related "assessment" questions which, in turn, drive the design of the estuarine component of the IWRAP. Table H1 shows the relationship between these factors in generating the final assessment questions recommended by the SAP. ***Note: Because the assessment questions for Levels 2 and 3 are identical, this table is applicable to both levels.***

Table H1. Relationships between quantifiable recovery objectives, management questions and issues, and scientific and assessment questions for Level-2 and –3 estuarine assessment activities.

HYDROLOGY

Quantifiable Recovery Objective	Management Question	Management Concerns	Scientific Question	Assessment Question
Recover physical processes: *Hydroperiod*	What is the condition of estuarine wetlands on a regional scale?	Have there been any modifications to hydroperiod?	What is the distribution of deviations from inferred natural (historic) conditions of the duration of mouth opening southern California estuaries?	What percent of estuaries have modified inlet conditions relative to their historic condition as indicated by the frequency of annual opening-and-closing cycles (normalized for climatic variation)? What is the effective tidal range in estuaries, and how is it changing over time?
Recover physical processes: *Water source*		What is the extent of channelization, entrenchment, engineered channels or modifications to flow?	What are the spatial and temporal patterns of salinity in coastal wetlands, and how are they changing over time?	What is the distribution of salinity condition of estuaries, in terms of spatial and temporal fluctuations within and between them, over time?

SEDIMENT

Quantifiable Recovery Objective	Management Question	Management Concerns	Scientific Question	Assessment Question
Recover physical processes: *Sediment yield*	What is the condition of estuarine wetlands on a regional scale? (cont'd)	What is the extent of problems related to erosion, excessive sedimentation or scouring?	What percentage of estuaries are aggrading or degrading, and how is this changing over time?	What is the decadal change in areal extent and spatial distribution of wetland habitat types in southern California coastal watersheds on a decadal time frame at a base imaging scale of 1:48,000 or smaller? How are estuarine bathymetry, intertidal elevations, and marsh habitat, as indicators of net sediment budget, changing over time?

Table H1. (Cont.)

CONTAMINANTS

Quantifiable Recovery Objective	Management Question	Management Concerns	Scientific Question	Assessment Question
Recover physical processes: *Cycling of macro and micro nutrients*	What is the condition of estuarine wetlands on a regional scale? (cont'd)	What are the trends in nutrient enrichment and eutrophication in estuaries and streams?	What proportion of estuaries are eutrophic, and how is this changing over time?	How are the distributions of chlorophyll *a* and phaeophyton in surficial (0-1 cm) unvegetated subtidal sediments, and in the water column, changing over time?
				How are the distributions of macroalgal extent and biomass in intertidal areas changing over time?
				How is the distribution of water-column chlorophyll *a* in the region's estuaries changing over time? What is the extent and distribution of hypoxia or anoxia across the region's estuaries, and how are the spatial and temporal patterns changing over time?
Recover physical processes: *Contaminant cycling*		What is the extent to which contaminants are present in surface waters and soils?	What is the distribution of estuarine contaminant levels (including metals, pesticides, and hydrocarbons), and how is this changing over time?	How are the distributions of labile and total phosphorus in subtidal marsh sediments changing over time (in relationship to grain size, organic carbon, iron and/or aluminum content)?
				How are the distributions of inorganic and organic nitrogen in subtidal marsh sediments changing over time (in relationship to grain size, organic carbon, iron and/or aluminum content)?
				How are the distributions of sediment heavy and trace metals in subtidal sediments changing over time (in relation to sediment organic carbon and Fe or Al content)?
				How are the distributions of sediment organochlorine pesticides in subtidal sediments changing over time (in relation to sediment organic carbon and Fe or Al content)?

Table H1. (Cont.)

<u>BIOTA</u>

Quantifiable Recovery Objective	Management Question	Management Concerns	Scientific Question	Assessment Question
Recover biological processes: *Maintain native species biodiversity* *Maintain spatial distribution of flora and fauna within wetland habitat* *3) Maintain trophic level interactions and food web linkages*	What is the condition of estuarine wetlands on a regional scale? (cont'd)	What is the status of the wetland plant community (community composition) in terms of health? 2) What are the distribution and abundance of invasive plants in wetlands?	What is the status of estuarine plant communities in the region, and how is it changing over time?	What is the distribution of native and nonnative plant species diversity, abundance, and relative percent cover at five index locations within the marsh plain at the end of the growing season (~September)?
				What is the distribution of CRAM Attribute scores in estuaries? What is the depth distribution of eelgrass (*Zostera* spp.), and how is it changing over time?
		1) What is the health of native animal communities? 2) What are the distribution and abundance of fauna that serve as prey items for birds/fish?	What is the status of estuarine invertebrate communities in the region and how is it changing over time?	What is the community composition of infaunal organisms for subtidal areas of southern California estuaries?
Recover biological processes: *Maintain native species biodiversity* *Maintain spatial distribution of flora and fauna within wetland habitat* *3) Maintain trophic level interactions and food web linkages*	What is the condition of estuarine wetlands on a regional scale?	What is the health of native animal communities?	What is the status of fish communities in the region, and how is it changing over time?	What is the distribution of species diversity and abundance values of native and of non-native fishes in two strata (high marsh and low marsh) of southern California coastal lagoons and estuaries, and how is it changing over time?
		What is the health of native animal communities?	What is the status of estuarine bird communities in the region, and how is it changing over time?	What is the distribution of species richness and abundance values (community composition) of overwintering birds within the different ecological guilds of southern California's intertidal wetlands, and how is this changing over time?

Table H1. (Cont.)

BIOTA (cont.)

Quantifiable Recovery Objective	Management Question	Management Concerns	Scientific Question	Assessment Question
				What are the distributions in the number of advertising males of Belding's savannah sparrow in southern California estuaries, and how is this changing over time?
		What is the distribution and abundance of invasive animals species in wetlands?	What proportion of estuaries have invasive species above levels of concern, and how is this changing over time?	[*Derived from the results of the other biotic questions.*]

LANDSCAPE CONTEXT

Quantifiable Recovery Objective	Management Question	Management Concerns	Scientific Question	Assessment Question
Recover landscape ecological structure	What are the major stressors impacting condition of wetlands and how are they changing over time?	What are the priority stressors that need to be managed by wetland class or habitat type? 2) What are the effects of land use changes in the watershed on wetlands?	What are the sources of anthropogenic stress to wetlands, and how are they changing over time?	What is the change over time in the distribution of landscape development intensity indices for the upstream and unique catchment of the estuary?
				What is the change over time in the percent impervious surface for the unique catchment of the estuary?
				What is the change over time in the population of the contributing watershed across all estuaries in the study area?
				What is the distribution of the number of stressors from the CRAM Stressor Checklist identified in estuaries in the study area?

Description of Assessment Activities, Data Output, and Management Implications

The following outlines the basic methodology recommended to address each of the assessment questions, along with expected data output and management implications.

1. **What percent of estuaries have modified inlet conditions relative to their historic condition as indicated by the frequency of annual opening-and-closing cycles (normalized for climatic variation)?**

   As background work, the historic inlet condition is first established for each estuary, and structural controls and major changes in watershed runoff and wave climate since the historic period are catalogued. Then, for ongoing monitoring, the inlet condition and geometry, flows, and water level are characterized. To do this, the inlet condition and water level are continuously monitored until the mouth closes. Monitoring is then reinitiated during the late fall until the mouth opens**.** From this information, the duration of open condition, or ratio of open:closed condition, is computed. The condition of the mouth is monitored using pressure transducers on bridges and/or moorings, at three different locations per estuary, in order to establish water-surface elevation. Existing fixed cameras (*e.g.,* Watch the Water™) are used to monitor the condition of the mouth.

   A more economical, alternative, approach to monitoring this indicator can incorporate the concept of relying on information about day-to-day condition of the mouth from the wetland managers, who are in a position to record the state of the mouth throughout the year. This information could be used to generate a moving average of inlet condition over 5-year spans, and be compiled at that interval as part of the regional survey for the IWRAP. If funding is insufficient to subsidize this work, local watershed groups could potentially be tapped into to provide information on this indicator. The wetland manager of every probabilistically selected estuary should be asked if he/she would be in a position to collect this data for five years, if this is not already a part of the routine monitoring at the estuary.

   The SAP recommends that the estuarine mouth opening-and-closing cycle be assessed (or information compiled) once every 5 years for 30 estuaries, and selected in a random, probabilistic fashion, with "estuary" as the sampling unit. Assessment outputs for this question is a bar chart showing the percentage of estuaries that fall in various bins representing different degrees of deviation of this value from historic condition (expressed in number of days the inlet is open). The change in the relative percentages of estuaries falling into each of these bins over successive sampling cycles is an indication of the effectiveness of management efforts to control inlet condition, and an indication of whether there is a trend toward a return to historic hydroperiod through tidal action.

2. **What is the effective tidal range in estuaries, and how is it changing over time?**

   The background work required in order to evaluate effective tidal range is to determine the basic shape and bathymetry of the system and cross-sectional topography of the tidal channels, to assess barrier beach or tidal inlet conditions, and to understand the effects of other factors confounding the hydrology of the system (such as culverts, tide gates, levees, and berms). Monitoring then involves measuring water-surface elevation and flow velocities at index locations (mouth, main channel, and tidal channels), over both spring and neap tidal cycles. To do this, probes and/or acoustic Doppler profilers (ADPs) are installed in each sampled estuary during the index period. These data are used in conjunction with information about general bottom/channel topography to understand how water effectively circulates throughout the estuary and tidal channels.

The SAP recommends that tidal range be assessed once every 5 years for 30 randomly selected estuaries, with "estuary" as the sampling unit.

3. **What is the distribution of salinity condition of estuaries, in terms of spatial and temporal fluctuations within and between them, over time?**

   To assess salinity, sondes (water column chemistry and physical parameter measuring devices) should be deployed at the head of each estuary over two full tidal cycles during the dry season to get an estimation of urban augmentation of freshwater into the system. Sondes should be checked on a weekly basis during this time. Water samples should be collected during the weekly sonde checks and measured with a handheld refractometer in order to monitor the accuracy of the sonde salinity data, at intervals. Parameters measured by the sondes should include, at a minimum, temperature, conductivity, and depth. The device's primary function will be to detect how the conductivity and temperature of the water column changes relative to depth, and this information, in turn, will be used to calculate water salinity.

   The SAP recommends that salinity be assessed once every 5 years at 30 randomly selected estuaries, with "estuary" as the sampling unit. Assessment output for this question is a bar chart showing the percentage of sites that fall within each of the salinity categories: hypersaline, euryhaline, oligohaline, and fresh. The change in the relative percentages of sample sites falling into each of salinity categories over successive sampling cycles is an indication of the effectiveness of management efforts relating to freshwater and tidal flows into estuaries.

4. **How is the distribution of water-column chlorophyll *a* in the region's estuaries changing over time?**

   For chlorophyll *a*, fluorometers should be deployed at the head of each estuary, over two consecutive tidal cycles during the dry season, so as to cover both spring and neap tides. Ideally, the fluorometers should be co-located with the salinity sensors (see question 3, above). Fluorometers should be checked on a weekly basis during this time Water samples should be collected during the weekly checks in order to monitor the accuracy of the sonde-fluorometer chlorophyll *a* data, at intervals.

   The SAP recommends that water-column chlorophyll *a* be assessed once every 5 years at 30 randomly selected estuaries, with "estuary" as the sampling unit. Assessment output for this question is a bar chart showing the percentage of sites that fall within each of several chlorophyll *a* abundance categories (ranges). The change in the relative percentages of sample sites falling into each of the categories over successive sampling cycles can provide an indication of the effectiveness of management efforts relating to nutrient enrichment in estuaries.

5. **What is the extent and distribution of hypoxia or anoxia across the region's estuaries, and how are the spatial and temporal patterns changing over time?**

   Dissolved oxygen (DO) should be assessed by deploying data sondes to measure DO at the bottom of the water column, at the head of each estuary, over two consecutive tidal cycles during the dry season, so as to cover both spring and neap tides. Ideally, the DO sensor should be co-located with the salinity and chlorophyll a sensors (see questions 3 and 4, above). DO should be tested with a DO meter during the weekly sonde checks in order to monitor the accuracy of the sonde DO data.

The SAP recommends that DO be assessed once every 5 years at 30 randomly selected estuaries, with "estuary" as the sampling unit. Assessment output for this question is a bar chart showing the percentage of sites that fall within each of several DO categories (ranges). The change in the relative percentages of sample sites falling into each of the DO categories over successive sampling cycles can provide an indication of the effectiveness of management efforts relating to eutrophication in estuaries.

6. **What is the decadal change in areal extent and spatial distribution of wetland habitat types in southern California coastal watersheds on a decadal time frame at a base imaging scale of 1:48,000 or smaller?**

   The change in areal extent and spatial distribution of wetland habitat types is determined through interpretation and GIS analysis of the decadal regional wetlands inventory mapping.

   The SAP recommends that areal extent and spatial distribution of wetland habitat types be assessed throughout the entire WRP study area once every 10 years. In addition to aerial imaging and maps of habitat types, assessment output for this question includes a pie chart depicting the relative abundance (acreages) of estuarine habitat types across the entire study area. Furthermore, because each estuary will be sampled during each sampling cycle, they can each be tracked over time to determine how management efforts in the estuary, and contributing watershed, are affecting the relative abundance of habitat types. This information is important, because changes in habitat types (conversion) can be an indication of stresses to the estuary, in terms of excessive sedimentation or erosion, severe alterations to hydrology, or biological invasions. In addition, several estuarine animal species are dependent on specific habitat types. Therefore, regional reduction of a given habitat type could result in negative consequences to the local abundance of certain species. Finally, habitat change can be reflective of sea-level rise, and many agencies have become concerned about the probable consequences of this phenomenon in the face of global warming, thus making this type of assessment highly relevant from multiple perspectives.

7. **How are estuarine bathymetry, intertidal elevations, and marsh habitat, as indicators of net sediment budget, changing over time?**

   Information from habitat mapping (from Level-1 activities), elevation (via remote sensing, such as LIDAR), and bathymetry will be used in concert to generate integrative measures of net sediment accumulation. Bathymetric data are collected along multiple transects traversing the estuary across the upper, mid, and lower estuary using a shallow-draft boats equipped with multi-beam sonar.

   The SAP recommends that bathymetry/elevation and habitat type/extent be assessed at all estuaries once every 10 years, but the mapping should be redone earlier if an El Nino or 25-year (or greater) event impacts the region. Assessment outputs for this question are bathymetric/elevation/habitat maps of each estuary to facilitate an analysis of changes in depth of each estuary over time, and to provide an assessment of the overall sediment budget across the estuary, both in the marsh plain, and in subtidal areas.

8. How are the distributions of constituents of subtidal marsh sediments changing over time?

a. How are the distributions of chlorophyll *a* and phaeophyton in surficial (0- 1 cm) subtidal sediments, and in the water column, changing over time?

b. How are the distributions of labile and total phosphorus in subtidal marsh sediments changing over time (in relationship to grain size, organic carbon, iron and/or aluminum content)?

c. How are the distributions of inorganic and organic nitrogen in subtidal marsh sediments changing over time (in relationship to grain size, organic carbon, iron and/or aluminum content)?

d. How are the distributions of sediment heavy and trace metals in subtidal sediments changing over time (in relation to sediment organic carbon and Fe or Al content)?

e. How are the distributions of sediment organochlorine pesticides in subtidal sediments changing over time (in relation to sediment organic carbon and Fe or Al content)?

For the assessment questions under 8 a-e, sediment samples are analyzed for their constituents. Thirty sampling sites are drawn in a random, probabilistic way from a sample frame of subtidal acreage within each of two estuarine size classes, large and small (for a total of 60). At each site, sediments are collected and analyzed for constituents. The SAP recommends that sampling be conducted once every 5 years. Assessment outputs for this question are the cumulative distribution functions for levels of sediment constituents within the study area. In addition, pie charts are used to show what percentage of estuarine acreage falls within different toxic-effects categories for constituents with established thresholds (such as metal contaminants).

9. How are the distributions of macroalgal extent and biomass in intertidal areas changing over time?

Thirty sampling sites should be drawn in a probabilistic way from a sample frame of intertidal acreage within each of two estuarine size classes, large and small (for a total of 60 points). The SAP recommends that sampling be conducted once every 5 years.

For measurement of macroalgal extent, there are two possibilities. It can be measured in the field using a quadrat with intercept points to score presence/absence, with quadrat placement at several locations along a transect. The transects can be located where the probabilistically selected intertidal sampling points fall. A second possibility is to use remote sensing to determine macroalgal percent cover at the level of the estuary. If both methods are used, the field data can be used to calibrate or validate the remote sensing data. For biomass, a sample is collected using a cylinder of fixed diameter placed on the benthos in the center of each quadrat along the same transects used for assessing macroalgal extent. Samples are cleaned of macroscopic debris, and sorted to species. Each species is dried to a constant weight, and macroalgal biomass is normalized to area.

Assessment outputs for this question are bar charts corresponding to varying levels of macroalgal percent cover and biomass within the study area. Management use of this information is an understanding of effectiveness of management actions addressing nutrient enrichment.

10. What is the distribution of native and nonnative plant species diversity, abundance, and relative percent cover at five index locations within the marsh plain at the end of the growing season (~September)?

Plant species are recorded along transects arrayed at fixed positions within 3rd-order tidal-channel drainage basins (based on the method used for the EMAP Western Pilot 2002 assessment) to yield information on species diversity, abundance, and relative percent cover across varying moisture regimes.

Thirty (30) sampling points, each, for the large and small estuarine classes, are randomly chosen. Within the basin encompassing each point, plant species relative percent cover data are collected from transects arrayed at two distances from the main channel, at both the foreshore and mid marsh (for a total of four), and a fifth transect placed parallel to the backshore. The SAP recommends that this indicator be assessed at the 60 total, randomly selected basins once every 5 years.

Because there are currently no established "thresholds" of condition established for native species richness, invasive species relative percent cover, or any of the other types of data that can be generated from the this type of study, assessment outputs for this question are bar-graph representations of the frequency of different bins of values for each of these variables, expressed in terms of percent of 3rd-order drainage basins. Sample bin widths for native species richness are 0, 1-2, 3-4, 5-6, and >6, and for relative percent cover of invasive species, are 0, 1-5, 6-20, 21-40, and 41-100. The change in relative abundances in each of the bin classes from sampling cycle to sampling cycle is an indication of the effectiveness of management practices in the region's estuaries, and their surrounding watersheds, that affect estuarine vegetation and habitat.

11. What is the distribution of CRAM Attribute scores in estuaries?

CRAM "assessment areas" are the discrete geographic units within which CRAM assessments are conducted. The CRAM manual (Collins *et al.* 2006) provides guidance on how to delineate an assessment area. The basic rule of thumb to do this is the to draw a boundary around areas that have distinct hydrology. Because of the way that assessment areas are defined, a given wetland can be composed of several distinct, adjacent assessment areas, which, cumulatively make up the entire acreage of the wetland. Whereas a large estuary may be comprised of several assessment areas, a very small estuary will often constitute a single CRAM assessment area in and of itself.

To conduct a Level-2 assessment using CRAM, 30 sampling points are probabilistically selected within each of the two estuarine size classes (for a total of 60 points) once every five years, and CRAM assessment areas are delineated around each point. CRAM assessments are conducted within each assessment area.

Because there are currently no "thresholds" of condition established for CRAM attribute scores, assessment outputs for this question are bar-graph representations of the frequency of different bins of values for each of the CRAM attributes, expressed in terms of percent of CRAM assessment areas. The changes in relative abundances in each of the bin classes from sampling cycle to sampling cycle are an indication of the effectiveness, at the level of the region, of management practices in the region's estuaries, and their surrounding watersheds, that affect estuarine condition with respect to hydrology, physical structure, biotic structure, and buffer and surrounding landscape.

12. What is the community composition of infaunal organisms for subtidal areas of southern California estuaries?

Infaunal invertebrates are collected from subtidal portions of estuaries and Shannon-Weiner Index values are calculated for each site. To select sampling locations, thirty sampling sites are drawn in a random, probabilistic way from a sample frame of subtidal acreage within each of two estuarine size classes, large and small (for a total of 60 sites). At each site, infauna are collected and identified. The SAP recommends that this sampling be conducted once every five years.

Because there are currently no established "thresholds" of condition established for infaunal invertebrate community composition, assessment outputs for this question are bar-graph representations of the frequency of bins corresponding to different ranges of Shannon-Weiner Index values. Results of this assessment provide information about the infaunal community that can be an indication of the complexity of the estuarine food web and its ability to support a diverse array of wildlife, and also a possible indication of anthropogenic stressors to the wetland in terms of the presence/absence of specific infaunal taxa.

13. What is the distribution of species diversity and abundance values of native and of non-native fishes in two strata of southern California coastal lagoons and estuaries, and how is it changing over time?

At low tide, channels are blocked off with blocking nets. A seine is run up and down the blocked-off portion of the channel until virtually all fish have been caught and held in buckets. All fish captured are counted, sexed, and measured, and species of each is recorded, after which they are returned to the channel. This process is repeated at two locations throughout each estuary, one within the high marsh zone, and one within low marsh, so as to capture the diversity of fish in different channel types.

The SAP recommends that fish diversity be assessed at 30 randomly selected estuaries, with "estuary" as the sampling unit, once every 5 years during the summer, at two different channel-depth strata: one near the mouth, and one in the mid-tidal range. In addition to fish community composition information, this sampling protocol also provides information about the ability of each estuary to serve as a flatfish nursery grounds, based on the presence and abundance of flatfish spawn. Assessment outputs for this question include bar graphs showing the percentage of estuaries with different ranges of species diversity values and ratios of abundances of non-native to native fishes, as well as the percent of estuaries that support flatfish nursery grounds. This provides information about the fish community that can be an indication of the complexity of the estuarine food web and its ability to support a diverse array of wildlife, as well as a possible indication of anthropogenic stressors to the wetland in terms of the presence/absence of specific fish taxa.

14. What is the depth distribution of eelgrass (*Zostera* spp.), and how is it changing over time?

For each sampling site, the maximum and minimum depth of eelgrass (*Zostera* sp.) beds are recorded using an average of 12 transects oriented perpendicular to shore. The transects are surveyed using acoustic techniques (*e.g.* side-scan or single-beam sonar) or diving.

Thirty sampling locations should be drawn probabilistically from a sample frame of eelgrass habitat within each of two estuarine size classes, large and small (for a total of 60). A set of data-collection transects is then oriented relative to each of the sampling sites. Sampling should be conducted once every 5 years. Assessment outputs for this question include bar graphs showing the percentage of eelgrass habitat acreage with varying ranges of both minimum and maximum depth of eelgrass beds. Various studies have demonstrated a negative correlation of bottom depth of eelgrass growth with light quality and quantity. Dennison *et al.* (1993) found that trends in the lower limit of eelgrass can be a predictor of ecosystem health. This indicator will therefore serve management needs by providing an integrative indicator of overall health of the subtidal ecosystem, as well as a measure of habitat quality for estuarine fish species associated with eelgrass beds.

15. What is the distribution of species richness and abundance values (community composition) of overwintering birds within the different ecological guilds of southern California's intertidal wetlands, and how is this changing over time?

The SAP recommends that community composition of overwintering birds be assessed by conducting bird counts at all estuaries that support overwintering bird populations once every five years. The assessment should be conducted in the winter, in the early morning, and at low tide. To the greatest extent possible, the window of time during which the assessment occurs at different estuaries should be very narrow, so as to limit the possibility of double-counting birds as they migrate along the coast.

This type of assessment is already ongoing at a number of study-area estuaries through grass-roots efforts, notably of local chapters of the Audubon society (*i.e.*, the annual Christmas Bird Count). The SAP recommends that bird counts be conducted by teams of existing bird count volunteers who are "trained", organized, and whose work is supplemented by contractors hired by IWRAP. This involves developing a mechanism that can encourage and support the implementation of a standardized assessment protocol for these groups to use, as well as a means for centralizing the data submittal process, and subjecting the data to quality-assurance review, so that these data can be incorporated into the IWRAP. Because this question focuses on migratory birds, the study region itself is only part of the equation that determines the health of the populations of the species being monitored. However, changes in abundances of overwintering birds, and relative abundances of constituent species, can provide clues as to the extent and quality of overwintering habitat provided by the study region to these migratory birds. It can also provide information about the quality and quantity of food items for these species supported by southern California estuaries. Assessment outputs for this question include bar graphs showing the percentage of estuaries with different ranges of overwintering bird species diversity values, and numbers of individuals, per guild.

16. What are the distributions in the number of duetting pairs of light-footed clapper rail in southern California estuaries, and how is this changing over time?

Clapper rails are monitored by spring call counts during March through early May using Zembal *et al.*'s method of assessing density of mated pairs of light-footed clapper rail (Zembal and Massey 1981, 1985; Zembal 1992). Where light-footed clapper rails are common, all locations of spontaneous calls are mapped. In those marshes with few rails or in long, narrow channels and habitat strips, tape-playback is used to solicit a response from territorial rails. Duets and "clappering" calls are treated as indications of territoriality. Observations of rails are recorded and mapped.

The SAP recommends that the number of duetting pairs of light-footed clapper rail be assessed at 30 randomly selected estuaries, with "estuary" as the sampling unit, once every 5 years. Assessment output includes the number of sites that support clapper rails, the number of duetting pairs in the region, and the number of duetting pairs for each site. Year-to-year trends in these values indicate whether clapper rail, and clapper rail habitat management measures across the region, are effective at improving survivorship and reproduction of the species. This information also serves as a reflection of general lower-to-mid- marsh habitat quality, and therefore, ecosystem health.

17. What are the distributions in the number of advertising males of Belding's savannah sparrow in southern California estuaries, and how is this changing over time?

Zembal's method of assessing density of advertising males of Belding's savannah sparrow (Zembal *et. al*., 1988) is employed. This involves walking transects through the *Salicornia* sp. habitat and recording bird localities and activity on maps.

The SAP recommends that density of advertising males of Belding's savannah sparrow be assessed at 30 randomly selected estuaries, with "estuary" as the sampling unit, once every 5 years. Assessment output includes the number of sites that support Belding's savannah sparrow, the number of advertising males in the region, and the number of advertising males for each site. Trends in the these values will indicate whether Belding's savannah sparrow, and Belding's savannah sparrow habitat management measures across the region are effective at improving survivorship and reproduction of the species. This information also serves as a reflection of general upper-to mid- marsh habitat quality, and therefore, ecosystem health.

18. What is the change over time in the distribution of landscape development intensity (LDI) indices for the upstream and unique catchment of the estuaries in the study area, the percent impervious surface for the unique catchment of the estuaries in the study area, and the population of the contributing watershed for each of the estuaries in the study area?

In order to answer these assessment questions, GIS analysis is conducted on aerial imaging and other landscape data layers such as land-use data and demographic data, addressing each question for each of the estuaries in the study area. The SAP recommends that these landscape attributes be assessed for all estuaries once every 10 years. Assessment outputs for each of these questions are bar graphs showing the percentage of estuaries falling into each different range of values (bins) for LDI Index, percent impervious surface for the unique catchment, and watershed population, respectively.

19. What is the distribution of the number of stressors from the CRAM Stressor Checklist identified in estuaries in the study area?

The SAP recommends that a CRAM stressor assessment be conducted at the CRAM assessment areas corresponding to 30 randomly selected points, within both the large and small estuarine size strata (for a total of 60 points), once every 5 years. Assessment output is the percent of CRAM assessment areas falling into bins representing different ranges in the number of CRAM stressors.

APPENDIX I: GUIDING PRINCIPLES FOR LEVEL-3 ASSESSMENT

Introduction

The purpose of this appendix is to provide an overview of Level-3 monitoring options, as well as an account of SAP guiding principles regarding Level-3 estuarine assessment.

Goals and Objectives for Level 3 Assessment

In contrast to Level-1 and Level-2 monitoring, the goal of Level-3 monitoring is to generate information about the *condition* of *specific estuarine sites*. Level-3 monitoring facilitates an assessment of trends in the condition of sites over time, and therefore provides information about the success of specific restoration efforts funded by the WRP and others, or the success of wetland regulatory efforts. It can also yield insight into the spatial heterogeneity of certain indicators (such as contaminants, and plant community composition) throughout a given estuary, as well as facilitate studies on the relationships between specific stressors and the condition of wetland ecosystems. Examples of several types of monitoring (mostly Level-3) conducted at estuaries in the study area are provided in Table I1, including information about overlap between the IWRAP and the existing monitoring in terms of common indicators assessed.

Table I1. Indicators common to IWRAP and selected existing monitoring efforts.

	IWRAP Indicators																					
	Resource Extent	Overall Condition	Hydrology			Physical Processes	Biochemistry - sediment constituents						Biology						Stressors			
Locations	wetland extent	CRAM attributes	inlet condition	tidal amplitude	salinity	sedimentation / erosion / bathymetry	chlorophyll a and phaeophyton	labile and total phosphorus	inorganic and organic nitrogen	heavy and trace metals	organochlorine pesticides	toxicity	plant diversity	sediment infauna	fish diversity	overwintering birds	light-footed clapper rail	savannah sparrow	landscape development	impervious surface	watershed population	other indicators monitored / comments
Arroyo Burro Lagoon														X	X							
Sweetwater/SD Bay																X						
Buena Vista Lagoon																X						
Camp Pendleton																	X	X				tidewater goby, western snowy plover
Carpinteria Salt Marsh														X	X	X						trematodes
Los Penasquitos Lagoon					X								X	X	X							porewater salinity, water quality (turbidity, coliform)
Malibu Lagoon																						
Mission Bay															X							
Mugu Lagoon				X				X	X						X	X	X	X				Ca. least tern, western snowy plover, saltmarsh bird's beak,
San Dieguito Lagoon				X									X	X	X							water temperature, pH
San Elijo Lagoon	X	X	X	X	X								X	X	X	X	X	X				
Santa Clara River Estuary																						water quality, habitat types
Seal Beach NWR																X	X	X				Ca. least tern, mammals, raptors
Tijuana River National Estuarine Research Reserve	X		X	X	X	X	X	X	X				X	X	X	X	X	X	X	X	X	herpetofauna, mammals, invertebrates, Ca. least tern, western snowy plover, porewater salinity
Agencies																						
USACE - Regulatory Branch	X		X			X				X	X		X									
CDFG South Coast Region																	X	X				Ca. least tern, western snowy plover, tidewater goby
EPA - Region 9	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
NMFS	X														X							
RWQCB - LA - "Bight program"					X					X	X	X		X	X							
RWQCB - LA - 401 program				X	X			X	X				X	X	X	X						temperature, pH, total suspended solids, turbidity; for plants: pre- and post-project condition in terms of % survival by plant spp and % cover
RWQCB - LA - NPDES program		X			X				X	X	X	X		X								
RWQCB - LA - SWAMP program		X			X			X	X	X	X	X		X								
RWQCB - SA - Planning Dept.	X	X																				
Wildlife Conservation Board	X					X							X			X			X			

Previous and Existing Level-3 Estuarine Assessment Efforts

Site-specific assessment of wetland condition is currently the most commonly practiced form of assessment in our region. This is because it is the form of assessment conducted for several different types of independent projects, from restoration and mitigation monitoring, to site-condition assessments conducted as part of the environmental review process when impacts to wetlands could occur. In addition, and specifically with respect to estuarine wetlands, there are a number of monitoring efforts being conducted in association with scientific studies of varying duration, which are geared toward understanding ecological processes. Examples of estuaries that support such studies include Mugu, Carpinteria Saltmarsh, San Dieguito Lagoon, and Peñasquitos Lagoon, among many others. In addition to this, there are long-term monitoring efforts at sentinel sites that are designed to generate information about climatic and ecological trends over extended periods, such as that which has been taking place at Tijuana Estuary, as part of the National Estuarine Research Reserve monitoring program.

SAP Recommendations for Level-3 Estuarine Monitoring

There are three possible approaches to Level-3 monitoring. One is to use either all, or at least a large subset of, the indicators that were selected for Level-2 monitoring, but intensifying the sampling of these indicators within sites. Under this scenario, the difference between the two levels of monitoring would be that, for Level 3, the data might be collected at a sufficient number of locations *within* a given estuary in order to generate a meaningful estimate of the condition of that site as a whole. This would be accomplished by sampling many locations within an estuary in which Level-3 work is being conducted and could potentially include additional sampling times of year in those estuaries, depending on the indicators being investigated. Level-3 monitoring using the same Level-2 indicators is ideal, because it would facilitate an estimation of the condition of a specific site relative to the condition of the region as a whole, at each sampling cycle, thus providing a context within which to interpret the results of the Level-3 assessment. Another benefit of this approach is that any Level-2 points that fall within a given estuary could potentially also be used to contribute to a Level-3 assessment within the same estuary, thus providing an economy of sampling effort. In order to make this latter approach most effective, it would be desirable to conduct the Level-3 assessment more or less concurrently with (and coordinated with) the Level-2 work, even if there are two different sampling teams involved.

Other Level-3 effort options include looking at non-Level-2 indicators that are specific to the restoration goals of a given site (*e.g.*, restoring fish passage). Additionally, Level-3 could include special studies geared toward understanding ecological processes and how they explain why certain approaches to restoration succeed or fail, or exploring stressor-response relationships, in order to understand novel approaches to improving the condition of wetland resources. Any such "special studies" need to be developed on a case-by-case basis, based on the needs of a given site, and will therefore not be discussed in any further detail in the present document. It should be noted, however, that information derived from either of the two latter types of Level-3 monitoring could result in the addition of new Level-2 IWRAP indicators at some future date.

The SAP recognizes that, ideally, Level-3 monitoring would consist of monitoring the same indicators recommended for Level-2, but at a higher spatial and temporal intensity, so as to provide assessments representative of specific sites as a whole (just as Level-2 generates estimates of the condition of the *region*, as a whole). This would allow site-specific evaluations to be conducted that are consistent with, and support, the Level-2 regional monitoring. However, it may not always be possible for this level of intensity of assessment to be conducted at individual sites. Therefore, a reasonable alternative to this approach would be to limit monitoring activities to a smaller set of targeted (preferably fixed) locations within sites where Level-3 monitoring is to be conducted.

The SAP suggests that some of the same indicators recommended for Level-2 monitoring should be incorporated in Level 3, *but the primary indicators chosen should be those that answer project-specific questions*. Such questions may address causative factors for wetland condition, or examine stressor-response relationships (*e.g.*, as they relate to performance standards), in contrast to the kinds of indicators that are of interest for ambient monitoring. The minimum core indicators for use in Level-3 monitoring that are recommended by the SAP are: habitat extent and CRAM scores (as part of *Project Tracking*, see below), inlet condition, tidal range, salinity, dissolved oxygen, and plant community composition, as well as any Level-2 indicators that are affected by actions (*e.g.*, dredging) taken pursuant to a project associated with the site. Because at least a subset of the same set of assessment questions and indicators recommended for Level 2 are prescribed for Level-3 monitoring, they are not reiterated in this Appendix.

Density of submerged aquatic vegetation (SAV), particularly in the form of eelgrass (*Zostera* spp.) beds in shallow subtidal and deepwater habitats, is an important indicator of estuarine condition because eelgrass beds constitute a crucial component of habitat for some estuarine fishes, and can also serve as a water-quality indicator. While information about the *extent* of these beds will be collected on a decadal basis as part of Level-1 IWRAP monitoring, the *density* of eelgrass and other submerged aquatic vegetation is not currently included as a Level-2 indicator. Shoot density varies with site, substrate, depth and other biological factors making it less useful as a metric of regional condition. However, shoot density is a useful metric for evaluating specific site condition and should be included as a Level-3 indicator. This type of Level-3 monitoring for eelgrass is currently being conducted, or has recently been conducted, in Mission, San Diego, Newport, Anaheim, and San Pedro Bays, Long Beach and Los Angeles Harbors, and Agua Hedionda and Batiquitos Lagoons. The SAP recommends that IWRAP take advantage of existing eelgrass monitoring efforts to the greatest extent possible. Furthermore, it is recommended that projects relating to eelgrass be incorporated into Level-3 Project Tracking (see below).

Project Tracking

An assessment activity recommended by the SAP that is specific to Level-3 monitoring is the tracking of wetland and riparian habitat losses and gains, and changes in condition, occurring through development impact, restoration, conservation or mitigation projects.

The SAP used priority Management Concerns/Questions as a starting point and incorporated their relationship to the WRP Quantifiable Recovery Objectives (Sutula *et al.* 2002) in order to generate "scientific" questions, and their related "assessment" questions which, in turn, drive the design of the estuarine component of the IWRAP. Table I2 shows the relationship between these factors in generating the final Project Tracking-related assessment questions established by the SAP.

Table I2. Linkages between quantifiable recovery objectives, management questions and issues, and scientific and assessment questions for Level-3 estuarine assessment activities (*Project Tracking*).

Quantifiable Recovery Objective	Management Concerns/Questions	Scientific Questions	Assessment Questions
Maintain existing, and increase, wetland acreage; Recover habitat diversity to reflect historic distribution to the extent possible; Restore physical processes; Recover biological structure and function	How are development impacts or mitigation projects affecting the distribution and function of different wetland and riparian habitat types? How are WRP partners contributing to the recovery of regional wetland ecosystem?	What is the effect of development impact, restoration, and mitigation projects on the areal extent, spatial distribution, and condition of wetland and riparian areas by habitat type, and how are WRP partners contributing to the recovery of the regional wetland ecosystem?	What is the yearly change in areal extent, spatial distribution, and condition of wetlands and riparian habitat types areas in southern California coastal watersheds as a result of restoration, development impact, and mitigation projects?
		Are we achieving the goal of "no-net-loss" of wetland and riparian habitat based on net change in acreage and wetland condition for wetland class or habitat type?	What is the yearly change in areal extent, spatial distribution, and condition of wetlands and riparian habitat types areas in southern California coastal watersheds that are in protected status as a result of acquisition and conservation projects?

The recommended approach to addressing the management questions articulated in Table H2 is to track gains in wetlands that have been placed in protected status (as a results of acquisition or conservation easements) and to map wetland and riparian gains and losses associated with each development impact, mitigation, or restoration project. At a minimum, in addition to tracking changes in wetland and riparian habitat *extent* through projects, the SAP recommends that CRAM be used to measure and track changes in *condition*, as well.

Evaluation of Existing Efforts

Currently, there is a lack of consistent tracking of wetland and riparian acreage gains and losses that are occurring through *projects*. The Army Corps of Engineers, California Department of Fish and Game, Regional Water Quality Control Boards, and California Coastal Commission regulate impacts resulting from the loss, and mitigation, of wetlands acreage. WRP partners including both agencies and non-profits are involved in a variety of wetland restoration activities that result in an increase of wetland acreage. Currently, these gains and losses in wetland acreage are not tracked in a centralized database.

In addition, there is no systematic accounting of wetland or riparian acreage that has been put into protected status as a result of acquisition or conservation projects (*i.e.*, conservation easements, etc.). This makes it difficult to quantify an important positive impact that WRP partners are having on the regional wetland ecosystem.

San Francisco Estuary Institute, Wetlands and Water Resources, and Point Reyes Bird Observatory Conservation Science, on behalf of the San Francisco Bay Wetlands Recovery

Program, are developing a system to track wetland acreage gains and losses through projects. The *Bay Area Wetland Project Tracker* provides free public access to information about the location, size, sponsors, habitats, contact persons, and status of wetland restoration, mitigation, creation, and enhancement projects in the San Francisco Bay Area (www.wrmp.org/projectsintro.html). Planned and completed wetland projects are displayed on an interactive regional map, and summary information is displayed alongside the map. More information can be accessed on separate project information sheets.

Recommended Assessment Activities

The SAP recommends that WRP partner agencies support the development and implementation of a southern California version of the *Bay Area Wetland Project Tracker*. Projects tracked would include the following types:

- Acquisition or conservation easements
- Development impact and mitigation
- Restoration of natural habitat
- Creation of constructed wetlands or riparian areas for water quality or flood control

Basic minimum information that should be collected with each project includes the following. The information collected should be made free to, and easily accessible by, the public through the WRP Information Station.

- Digital maps of wetland and/or riparian habitat *pre*- and *post*- project. Mapping methods should be the same as those used for region-wide mapping activities.
- Summary of wetland and/or riparian acreage preserved, created, mitigated, or lost by habitat type.
- Project status (completed, or in progress, or planned, with anticipated start and end dates)
- Summary project information (including sponsoring entity, project description, county, watershed, and basin information)
- Basic project documentation
- Overall site condition using CRAM

Information acquired through the Project Tracker can be used to generate the following:

- Raw digital geospatial data (maps) illustrating locations, area (size and shape), and characteristics of wetland and riparian habitat created or lost by development impacts, restoration and/or mitigation projects
- Yearly, or net, change over a specified time period in areal extent of wetland and riparian habitat types by geographic unit (i.e., sub-basin, basin, watershed, bioregion, region) due to restoration, development impact, and mitigation projects
- Raw digital geospatial data (maps) illustrating locations, area (size and shape), and characteristics of wetland habitat that have been put in protected status by conservation actions

- Yearly, or net, change over a specified time period in areal extent of wetland and riparian habitat types that are in protected status by geographic unit (i.e., sub-basin, basin, watershed, bioregion, region) due to conservation or preservation activities
- CRAM scores corresponding to each of the projects, as well as regional net changes in CRAM scores stratified by habitat, or project, types